Hon^{ble}

Hugh Percy

16059/B.

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NATURAL HISTORY,

GENERAL AND PARTICULAR,

BY THE

COUNT DE BUFFON,

TRANSLATED INTO ENGLISH.

ILLUSTRATED

WITH ABOVE 300 COPPER-PLATES,

AND OCCASIONAL

NOTES AND OBSERVATIONS.

BY WILLIAM SMELLIE,
MEMBER OF THE ANTIQUARIAN AND ROYAL
SOCIETIES OF EDINBURGH.

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NATURAL HISTORY.

ADDITIONS AND CORRECTIONS.

ADDITIONS to the Article concerning the Formation of the Planets, Vol. I. p. 59.

I.

On the diſtance of the Earth from the Sun.

IN p. 59. I ſaid, *That the earth is ſituated thirty millions of leagues from the ſun.* This was the general opinion of aſtronomers in the year 1745, when I compoſed the treatiſe on the formation of the planets. But later obſervations, and particularly thoſe derived from the tranſit of Venus over the ſun's diſc in 1769, ſhow that this diſtance of thirty millions ſhould be augmented three or four millions of leagues. It is for this reaſon that, in the *Epoques de la Nature*, I have always reckoned the mean diſtance of the ſun from the earth to be thirty-three millions of leagues, inſtead of thirty. This remark was neceſſary to prevent the ſuſpicion of my having contradicted myſelf.

I muſt farther remark, that the ſun is not only thirty-three or thirty-four millions of leagues diſtant from the earth, but, from the ſame obſervations, it has likewiſe been diſcovered that the volume of the ſun is a tenth part larger than was formerly ſuppoſed; and, conſequently, that the whole maſs of the planets is only an eight hundredth part of that of the ſun, and not a ſix hundredth and fiftieth part, as I had advanced from the information we poſſeſſed in the year 1745. This difference ſtrengthens the probability that the matter of the planets was projected from the body of the ſun.

II.

Of the Matter of the Sun and Planets.

I Had remarked, in p. 65. That *the opaque bodies of the planets were detached from the luminous matter of which the ſun is compoſed.* Theſe expreſſions are not correct; for the matter of the planets, when projected from the ſun, was equally luminous as that of the ſun itſelf, and the planets became not opaque till their ſtate of fluid brightneſs had ceaſed: The duration of this ſtate in ſeveral kinds of matter I determined by experiment; and, from analogy, I calculated the continuation of this bright ſtate in each of the planets [*]. Beſides, as the torrent of matter, projected from the body of the ſun by the comet, traverſed the immenſe atmoſphere of that luminary, it carried off the volatile, aqueous, and aerial parts of which the ſeas and atmoſpheres of the different planets are now compoſed. Hence we may conclude, that the matter of the planets is the ſame, in every reſpect, with that of the ſun, and that there is no other difference but in the degree of heat, which is extreme in the ſun, and greater or ſmaller in the planets, according to the compound ratio of their thickneſs and denſity.

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[*] See epoques de la nature.

III.

Of the relation between the Denſity of the Planets and their Celerity.

IN p. 75. I ſaid, that, *according to this relation between the celerity and denſity of the planets, the denſity of the earth ought not to exceed* $206\frac{7}{18}$, *inſtead of* 400, *which is its real denſity.* The denſity here aſcribed to the earth is too great with relation to the quickneſs of its motion round the ſun, and ought to be a little diminiſhed for a reaſon which had formerly eſcaped me. The moon, which, in this computation, ſhould be regarded as forming a part of the earth, is leſs denſe in the ratio of 702 to 1000, and the lunar globe is $\frac{1}{49}$th of the bulk of the terreſtrial. Hence, if the moon were as large as the earth, we ſhould diminiſh the denſity of the latter 400 in the ratio of 1000 to 702, which produces 281, *i. e.* 119 of diminution in the denſity 400. But, as the moon is only $\frac{1}{49}$th part of the bulk of the earth, it will produce only $\frac{119}{49}$, or $2\frac{5}{7}$ths of diminution. Conſequently, the denſity of our globe, with relation to its celerity, inſtead of $206\frac{7}{18}$, ought to be eſtimated at $206\frac{7}{18}+2\frac{7}{3}$ *i. e.* nearly 209. Beſides, we may ſuppoſe that our globe, at the beginning, was leſs denſe than it is at preſent, and that it is become much more compact both by cooling, and by the ſinking of vaſt caverns with which its interior parts abounded. This opinion accords with thoſe revolutions which happened, and ſtill continue to happen, both on the ſurface of the earth, and even at conſiderable depths. By the aid of this fact, we are enabled to explain the poſſibility that the waters of the ſea were formerly 2000 fathoms above thoſe parts of the globe which are now inhabited; for theſe waters would ſtill cover the whole ſurface of the earth, if, by immenſe depreſſions, different parts had not ſunk, and formed thoſe receptacles for the waters which at preſent exiſt.

If we ſuppoſe the diameter of the globe to be 2863 leagues, it would be two leagues more when covered with 2000 fathoms of water. This difference in the bulk of the earth, produced by the ſinking of the waters, gives an augmentation of a $\frac{1}{477}$th part of its denſity. This augmentation of the denſity, or diminution of the bulk of the globe, may be doubled, and perhaps tripled, by the ſinking and overturning of mountains, and the conſequent filling up of valleys; ſo that, ſince the waters fell upon the earth, its denſity may be ſuppoſed to have increaſed one hundredth part.

IV.

On the relation aſſigned by Newton between the denſity of the Planets and the degrees of Heat to which they are expoſed.

IN p. 145. I remarked, that, *notwithſtanding the regard due to the conjectures of Newton, I cannot help thinking that the denſities of the planets have a nearer relation to their celerities than to the degrees of heat to which they are expoſed.* From calculating the action of the ſolar heat upon the planets, it appears that this heat, in general, is inconſiderable, and that it has never produced any great change in the denſity of each planet; for the action of the ſolar heat, which is weak in itſelf, has no influence on the denſity of the matter of which the planets are compoſed, except at their ſurfaces. It cannot act on the internal parts, becauſe it penetrates to a very ſmall depth only. Hence the total denſity of a planet has no relation to the heat tranſmitted to it by the ſun.

It appears to be certain, therefore, that the denſity of the planets has no dependence on the ſolar heat, but, on the contrary, that their denſities have a neceſſary relation with their celerities, which laſt increaſe or diminiſh in proportion to their diſtances from the ſun. We have ſeen, that, at the general projection, the more denſe parts were not removed ſo far from the ſun as the leſs denſe. Mercury, which is compoſed of the moſt denſe matter projected from the ſun, remained in the neighbourhood of that luminary; while Saturn, which conſiſts of the lighteſt matter, is removed to a great diſtance from the ſun: And, as the moſt diſtant planets revolve round the ſun with greater celerity than thoſe that are nearer, it follows, that their denſity has a direct relation with their celerity, and ſtill more with their diſtance from the ſun. The diſtances of the ſix planets from the ſun are as 4, 7, 10, 15, 52, 95; and their denſities as 2040, 1270, 1000, 730, 292, 184. And, if we ſuppoſe the denſities to be in the inverſe ratio of the diſtances, they will be as 2040, 1160, 889½, 660, 210, 159. This laſt relation between their reſpective denſities is perhaps more juſt than the former; becauſe it ſeems to be founded on the phyſical cauſe which muſt have produced the difference of denſity in each planet.

ADDITIONS to the Article concerning Geography, Vol. I. p. 133.

I.

On the extent of Terreſtrial Continents.

PAGE 134. I ſaid, that *the longeſt line which can be drawn in the ancient Continent is about 3600 leagues.* By leagues I mean thoſe uſed in the environs of Paris, which are 2000 or 2100 fathoms long, and about 27 of them make a degree.

Beſides, though in this article of general geography, I endeavoured to reach that degree of exactneſs which ſubjects of that nature require; yet a few ſlight errors have eſcaped me. For example, 1. I have not uſed the names adopted or given by the French to ſeveral parts of America. I uniformly followed the Britiſh globes made by Senex, of two feet diameter, from which my charts were exactly copied. The Britiſh are more juſt than the French, with regard to countries they diſcover, or through which they travel. They preſerve the original name of each country, or that which was beſtowed on it by the firſt diſcoverers. We, on the contrary, often give French names to the countries we viſit, which is the cauſe of that obſcurity in the geographical nomenclature of our language. But, as the lines which traverſe the two Continents in their greateſt length are well marked, in my charts, by the two extreme points, and ſeveral other intermediate ones, whoſe names are generally adopted, no eſſential ambiguity can ariſe from this circumſtance.

2. I likewiſe neglected to give the calculation of the ſurface of the two continents, becauſe it is eaſily made on a large globe. But, as many perſons have expreſſed a deſire to ſee this calculation, I here ſubjoin that which M. Robert de Vaugondi tranſmitted to me at the time *. From

---

* Calculation of our Continent by geometrical leagues ſquare.

14 d.	14 d.	14 d.	14 d.	14 d.	
5 E	8 D	10½ C	12½ B	13½ A	14d
78750	80937	100625	113750	120312½	

Calculation of the left half.		Calculation of the right half.	
A × 3 =	360937½	A × 3 =	360937½
A × 3¼ =	421093¾	A × 1 =	120312½
B × 3½ =	398125	B × 1 =	113750
B × 4 =	455000	B × 4⅓ =	492916⅔
C × 2 =	201250	C × 1 =	100625
C × 3 =	301875	C × 4⅓ =	436041⅔
D × 1 =	80937½	D × 1 =	80937½
D × 2 =	161874	D × 4⅓ =	350729
E × 1 =	78750	E × 1 =	78750
E × ″⅐ =	11250	E × 4¼ =	334687½
	2471092¾		2469687

2471092¾
2469687

Difference 1405¾

Which is ſcarcely a degree and a half ſquare.

From this calculation it appears, that, on the left of the line of partition, there are 2471092$\frac{3}{4}$ of ſquare leagues, and 2469687 ſquare leagues on the right of the ſame line; and conſequently that the Old Continent conſiſts of about 4940780 ſquare leagues, which is not one fifth part of the earth's ſurface.

In the ſame manner, the part on the left of the line of partition in the New Continent, contains 1069286$\frac{5}{6}$ ſquare leagues, and that on the right of the ſame line conſiſts of 1370926$\frac{1}{12}$; in

Calculation of the Continent of America according to the ſame meaſures.

Calculation of the left half.		Calculation of the right half.	
D × 2 =	161965	D × 2$\frac{2}{3}$ =	215833$\frac{1}{3}$
C × 2 =	201250	C × 2$\frac{1}{4}$ =	225406$\frac{1}{4}$
B × 2 =	227500	A × ″$\frac{1}{5}$ =	24062$\frac{1}{2}$
A × ″$\frac{1}{2}$ =	60156$\frac{1}{4}$	A × 1$\frac{1}{5}$ =	144375
A × ″$\frac{2}{3}$ =	80208$\frac{1}{3}$	B × 2 =	227500
B × ″$\frac{4}{5}$ =	91000	C × 2$\frac{1}{6}$ =	218020
C × 1$\frac{1}{4}$ =	125801$\frac{4}{5}$	D × ″$\frac{1}{5}$ =	15750
D × 2 =	121406		
	1069286$\frac{5}{6}$		1070926$\frac{1}{12}$

	1070926$\frac{1}{12}$
	1069286$\frac{5}{6}$
Difference	1639$\frac{1}{4}$

Which is ſcarcely a degree and one fifth ſquare.

Superficies of the New Continent	2140213
Superficies of the Old Continent	4940780
Total -	7080993 ſquare leagues.

in all, about 2140213 ſquare leagues; which makes not one half of the ſurface of the Old Continent. As both Continents contain but 7080993 ſquare leagues, their ſuperficies is not near one third of the total ſurface of the globe, which is about 26 millions of ſquare leagues.

3. I ought to have mentioned the ſmall difference of inclination that ſubſiſts between the two lines by which I divided the two Continents. I contented myſelf with ſaying, that they were both inclined to the Equator, in oppoſite ſides, about 30 degrees, which is not the preciſe fact; for that of the Old Continent is a little more than 30 degrees, and that of the New a little leſs. If I had given this explanation, I ſhould have avoided the imputation of having drawn two lines of unequal lengths, under the ſame angle between two parallels; which would have proved, as an anonymous critic remarks *, that I am unacquainted with the elements of geometry.

4. I neglected to diſtinguiſh Upper from Lower Egypt; ſo that, in p. 137. and 138. there is the appearance of a contradiction. In the firſt of theſe paſſages, Egypt ſeems to be ranked among the moſt ancient lands, while, in the ſecond, it is reckoned among the moſt recent. I was wrong in not diſtinguiſhing, as I had elſewhere done, Upper Egypt, which is a very ancient land, from Lower Egypt, which is a very new territory.

II.

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* Lettres à un Americain.

II.

Of the Form of Continents.

With regard to the figure of Continents, I ſhall tranſcribe a paſſage from the ingenious author of the Philoſophical and Political Hiſtory of the two Indies.

'It is now thought to be certain,' he remarks, 'that the ſurface of the New Continent is not 'one half of that of the Old. Beſides, in their 'figure there are ſome ſtriking analogies.—They 'ſeem to form two immenſe bands of earth, 'which ariſe from the Arctic pole, terminate in 'the South, and ſeparated on the Eaſt and Weſt 'by the ocean that inveſts them. Independent 'of the ſtructure of theſe two bands, and of the 'counterpoiſe or ſymmetry which takes place in 'their figure; it is apparent, that their equili'brium depends not on their poſition; it is the 'fluctuation of the ſea which produces the ſtabi'lity of the earth. To fix the globe on its baſe, it 'was neceſſary to have an element which, by 'floating continually around this planet, ſhould 'counterbalance, by its weight, the other ſub'ſtances, and reſtore that equilibrium which the 'colliſion of the other elements might have diſtur'bed. Water, by its fluidity and gravity, is well

‘ fitted to ſupport that harmony and that balance ‘ of the different parts of the globe around its ‘ centre.

‘ If the waters which ſtill moiſten the bowels ‘ of the New Hemiſphere had not deluged its ‘ ſurface, man would ſoon have cut down the ‘ woods, drained the marſhes, and given conſiſtence to a watery ſoil.—He would have opened ‘ vents to the winds, and confined the rivers ‘ within their banks; the climate, of courſe, ‘ would have already been changed. But an ‘ uncultivated and thinly inhabited hemiſphere ‘ announces a recent land, while the waters ‘ which environ its coaſts ſtill creep ſilently ‘ through its veins.’

On this ſubject I ſhall remark, that, although there is more water on the ſurface of America than on that of other countries, we ought not to conclude from this circumſtance, that an internal ſea is contained in the bowels of this new land. We ſhould only infer from this number of lakes, marſhes, and large rivers, that America has been peopled long after Aſia, Africa, and Europe, where the quantity of ſtagnant waters is much leſs. Beſides, a thouſand other circumſtances concur in ſhowing, that the Continent of America in general ought to be regarded as new land, in which Nature has not had time to acquire all her powers, nor to exhibit them by a numerous population.

III.

Of the Terra Auſtralis, p. 140.

To what I have ſaid concerning the Terra Auſtralis, I ſhall add, that, within theſe few years, new attempts have been made to diſcover it, and that ſome points of it have been found after departing either from the Cape of Good Hope, or from the Iſle of France; but that theſe new voyagers have uniformly met with thick fogs, ſnow, and ice, in the 46th or 47th degree of South latitude. After converſing with ſome of theſe voyagers, and collecting all the information I could derive from other ſources, I perceived that they all agreed with regard to this fact, and that they found ice in much lower latitudes than is to be met with in the northern hemiſphere. They likewiſe uniformly met with fogs in the ſame latitudes where they found ice, though it was ſummer in theſe climates at the time the experiments were made. It is, therefore, extremely probable, that, below the 50th degree, it will be in vain to ſearch for temperate countries in the ſouthern hemiſphere, where the freezing cold is much farther extended than in the northern. The thick fog is produced by the preſence or neighbourhood of the ice. This fog conſiſts of minute particles of ſnow, which are ſuſpended in the air, and render it obſcure: It often accompanies the great floating maſſes of ice, and reigns perpetually in frozen regions.

Beſides, the Britiſh have lately ſailed round New Holland as well as New Zealand. Theſe ſouthern countries are more extenſive than the whole of Europe. New Zealand is divided into ſeveral iſlands; but New Holland ought rather to be regarded as a part of Aſia, than as an iſland belonging to the Southern Continent; for New Holland is only ſeparated from the land of the Papous, or New Guiney, by a narrow ſtrait, and the whole Archipelago, which extend ſouthward from the Philippine iſles, as far as the country of Arnhem in New Holland, and toward the weſt and ſouth, as far as Sumatra and Java, appears to belong as much to the Continent of New Holland, as to the ſouthern parts of Aſia.

Captain Cook, who ought to be regarded as the greateſt navigator of this age, and to whom we are indebted for an infinite number of new diſcoveries, has not only given a chart of the coaſts of Zealand and New Holland, but has likewiſe explored an immenſe tract of the ſouth ſea in the neighbourhood of America. He departed from the ſouth point of America on the 30th of January 1769, and he traverſed a great part of the ocean under the 60th degree, without diſcovering any land. From Captain Cook's chart we may perceive the great extent of ſea which he explored; and his tract demonſtrates, that, if any lands exiſt in this part of the globe, they muſt be far removed from the Continent of America; for New Zealand, which is ſituated between the 35th and 45th degrees, is very diſtant from America. But it is ſtill to be hoped, that other navigators, following the tract of Captain Cook, will traverſe the ſouthern ocean under the 50th degree, and that they will diſcover whether theſe immenſe regions, which extend more than two thouſand leagues, conſiſt of land or of ſea. However, I do not imagine that the ſouthern regions, beyond the 50th degree, are ſo temperate that any advantage could be derived to us from the diſcovery of them.

IV.

Concerning the invention of the Mariner's Compaſs, p. 153.

With regard to the invention of the Mariner's Compaſs, I have to add, that, from the teſtimony of Chineſe authors, of which M. le Rouſe and M. de Guignes have made an abridgement, it appears to be certain, that the polarity of the magnetic needle has been very anciently known to the inhabitants of China. The figure of theſe firſt compaſſes was thoſe of a man, who turned upon a pivot, and whoſe right arm pointed to the ſouth. The time of this invention, according to certain Chineſe chronicles, was 1115 years before the Chriſtian aera, and, according to others, 2700 *. But, notwithſtanding the antiquity of this diſcovery, it does not appear that the Chineſe had ever derived from it the advantage of making long voyages.

Homer, in the Odyſſey, tells us, that the Greeks employed the loadſtone to direct their navigation when they went to beſiege Troy; and this aera is nearly the ſame with that recorded in the Chineſe Chronicle. Hence we can no longer doubt, that the direction of the loadſtone toward the pole, and even the uſe of the mariner's compaſs in navigation, were known to the ancients at leaſt three thouſand years ago.

V.

Of the diſcovery of America, p. 155.

To what I ſaid, p. 155. concerning the diſcovery of America, a critic of more judgment than the author of *Lettres à un Américain*, has accuſed me of doing a kind of injury to the memory of ſo great a man as Chriſtopher Columbus.

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* See l'Extrait des Annales de la China, par Mrs Rouſe and de Guignes.

bus. ‘It is confounding,’ he remarks, ‘Columbus with his ſailors, to think that he could ‘believe the ſea roſe toward the ſky, and that ‘they perhaps touched each other on the ſouthern part of the globe.’ This criticiſm is extremely juſt. I ought to have ſoftened this fact, which I had extracted from ſome hiſtorical relation; for this great navigator, it is to be preſumed, muſt have had very diſtinct notions concerning the figure of the earth, which he derived both from his own voyages, and from thoſe of the Portugueſe to the Cape of Good Hope and the Eaſt Indies. It is well known, however, that Columbus, when he arrived at the New Continent, thought himſelf at no great diſtance from the eaſt coaſts of Aſia. As no man, at that period, had circumnavigated the world, he could not know its circumference, and did not imagine that the earth was ſo extenſive as it has been demonſtrated by later diſcoveries. Beſides, it muſt be acknowledged, that this firſt navigator toward the weſt, could not fail to be aſtoniſhed to find, that, when below the Antilles, it was impoſſible for him to gain the ſouthern regions, and that he was continually forced back. This obſtacle ſtill ſubſiſts. We cannot, in any ſeaſon, ſail directly from the Antilles to Guiana; becauſe the currents are extremely rapid, and conſtantly run from Guiana to thoſe iſlands. Ships ſail from Guiana to the Antilles in five or ſix days; but they require two months to return. In order to return, they are obliged to make a large circuit toward the Old Continent, from whence they direct their courſe toward the Terra Firma of South America. Theſe rapid and perpetual currents from Guiana to the Antilles are ſo violent that they cannot be ſurmounted by the aid of the wind; and, as this circumſtance is unexampled in the Atlantic ocean, it is not ſurſpriſing that Columbus, who, notwithſtanding all the reſources of his genius and knowledge in the art of navigation, could not advance toward the ſouthern regions, ſhould think that ſomething of a very extraordinary nature exiſted in this place, and perhaps that there was a greater elevation in this part of the ſea than in any other; for the currents from Guiana to the Antilles actually run with as much rapidity as if they deſcended from a height.

The motion of the following rivers, may give riſe to the currents from Cayenne to the Antilles.

1. The impetuous river of the Amazons, whoſe mouth is ſeventy leagues broad, and its direction more to the North than the South.

2. The river Ouaſſa is likewiſe rapid, has the ſame direction, and its mouth is nearly a league wide.

3. The Oyapok is ſtill more rapid than the Ouaſſa, paſſes through a greater tract of land, and its mouth is nearly of the ſame dimenſion.

4. The Aprouak has nearly the ſame extent of courſe and of mouth as the Ouaſſa.

5. The river Kaw is leſs extenſive both in its courſe and mouth; but, though it iſſues from a Savannah about twenty-five or thirty leagues from the ſea, it is extremely rapid.

6. The Oyak, which is a conſiderable river, divides into two branches at its mouth, and forms the iſland of Cayenne. This river, at the diſtance of twenty or twenty-five leagues, receives another called Oraput; it is very impetuous, and derives its ſource from a mountain of rocks, from whence it deſcends in rapid torrents.

7. One branch of the Oyak runs, near its mouth, into the river of Cayenne; and theſe two rivers, when united, are more than a league broad; the other branch exceeds not half a league.

8. The river of Kourou, which is very rapid, and not above half a league wide at the mouth, without reckoning the Macouſia, which, though it furniſhes much water, comes from no great diſtance.

9. The Sinamari is an impetuous river; it comes from a great diſtance, and its bed is pretty narrow.

10. The river Maroni, though it be very rapid, comes from a great diſtance. Its mouth is more than a league broad, and, next to the Amazon, it diſcharges the greateſt quantity of water,

water. It gives riſe to no iſlands; while the mouths of the Amazon and Oronoko are interſperſed with a great number.

11. The rivers of Surinam, of Barbiché, of Eſſequebé, and ſome others, till we reach the Oronoko, which is a very large river.

By the accumulations of mud and of earth brought down from the mountains by theſe rivers, it ſhould appear, all the valleys of this vaſt continent have been formed; in the middle of the continent there are ſome mountains, moſt of which have formerly been volcanoes, and are not ſufficiently elevated to allow their ſummits to be covered with ſnow or ice.

Hence it is apparent, that the united force of all theſe rivers gives riſe to that general current of the ſea from Cayenne, or rather from the Amazon, to the Antilles; and that this general current extends, perhaps, above ſixty leagues from the eaſtern coaſt of Guiana.

ADDITIONS to the article, Of the Production of Strata, Vol. I. p. 15.

I.

Concerning the Strata in different parts of the Earth.

WE have ſome examples of quarries and pits of conſiderable depths, of which the different ſtrata have been examined and deſcribed; ſuch as the pit of Amſterdam, which deſcends 232 feet, and that of Marly-la-ville, which is 100 feet deep. Many other examples might be given, if obſervers had agreed in their denominations. But ſome give the name of *marl* to white clay; others apply the term *flint* to round calcareous ſtones; and others give the denomination of *ſand* to calcareous gravel. Hence little advantage can be derived either from their reſearches or their long diſſertations on theſe ſubjects; becauſe we are under a perpetual uncertainty with regard to the nature of the ſubſtances they deſcribe. We ſhall, therefore, confine ourſelves to the following examples.

An excellent obſerver has written to one of my friends, in the following terms, concerning the ſtrata in the neighbourhood of Toulon: 'To the north of the city of Toulon,' he remarks, 'there is an immenſe quantity of ſtony

‘ matter, which occupies the declivity of the ‘ chain of mountains, and ſtretches through the ‘ valley from eaſt to weſt; and one part of it ‘ forms the ſoil of the valley, and loſes itſelf in ‘ the ſea. This ſtony matter is commonly called ‘ *ſaffre*; but it is that ſpecies of tufa which is ‘ denominated *marga toffacea fiſtuloſa* by natu‘raliſts. M. Guettard deſired me to furniſh ‘ him with all the information I could obtain ‘ concerning this ſaffre, as well as ſpecimens of ‘ the matter itſelf, that he might examine it, ‘ and give a detail of its qualities in his me‘moirs. I ſent them both; and I believe I have ‘ ſatisfied him; for he has thanked me for the ‘ information I communicated. He tells me, ‘ that he is to return to Provence and Toulon ‘ in the beginning of May. . . . . . . M. Guet‘tard, however, will probably give us nothing ‘ new upon this ſubject; for M. de Buffon has ‘ exhauſted it in the firſt volume of his Natural ‘ Hiſtory, under the article, *Proofs of the theory* ‘ *of the earth*; and it appears, that, in compo‘ſing this article, he had in his eye the moun‘tains of Toulon and their ridge.

‘ At the commencement of this ridge, which ‘ conſiſts of a more or leſs hard tufa, we ‘ find, in ſmall cavities of the nucleus of the ‘ mountain, quantities of very fine ſand, which ‘ are probably the balls mentioned by M. ‘ de Buffon. After breaking other ſuperficial

‘ parts of the nucleus, we find numbers of ſea-‘ ſhells incorporated with the ſtone. . . . . . I ‘ have ſeveral of theſe ſhells, the enamel of which ‘ is well preſerved. I will ſend them ſoon to ‘ M. de Buffon.’

M. Guettard, who has made more obſervations of this kind than any other naturaliſt, expreſſes himſelf in the following terms, when he treats of the mountains in the neighbourhood of Paris *.

‘ Below the vegetable ſoil, which exceeds ‘ not two or three feet, is placed a bed of ſand ‘ from four or ſix to twenty, and often thirty ‘ feet thick. This bed is commonly replete ‘ with ſtones of the nature of grind-ſtone. . . . ‘ In ſome diſtricts, we meet with detached maſ-‘ ſes of free-ſtone in this ſand bed.

‘ Below this ſand, we find a tufa, from ten ‘ or twelve, to thirty, forty, and even fifty feet ‘ thick. This tufa is not commonly of one e-‘ qual thickneſs. It is frequently cut by diffe-‘ rent ſtrata of ſpurious or clayey marl, of the ‘ *cos* which the workmen call *tripoli*, or of good ‘ marl, and even by ſmall beds of pretty hard ‘ ſtones. . . . . Under this bed of tufa are ‘ found thoſe which furniſh ſtones for building. ‘ Theſe beds vary in thickneſs: At firſt they ‘ exceed not one foot. In ſome diſtricts, three

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* Lettre de M. Buſſy á M. Guenaud de Montbeillard, *Toulon, Avril* 16. 1775.

‘ or four of them lie above each other. They ‘ are ſucceded by one of about ten feet, both the ‘ ſurface and interior parts of which are inter‘ſperſed with moulds or impreſſions of ſhells. ‘ It is followed by another about four feet, ‘ which reſts upon one from ſeven to eight, or ‘ rather upon two of three or four feet. After ‘ theſe beds, there are ſeveral others, which ‘ together form a maſs of at leaſt three fathoms. ‘ This maſs, after piercing a bed of ſand, is ſuc‘ceeded by clays.

‘ This bed of ſand is earthy and reddiſh, and ‘ is from two and a half to three feet thick. ‘ After this comes a bed of ſpurious clay of a ‘ blueiſh colour; it is a clayey earth mixed with ‘ ſand; the thickneſs of this bed is about two ‘ feet, and is followed by another of five, which ‘ conſiſts of a ſmooth black clay, the broken ‘ portions of which are nearly as brilliant as jet. ‘ Laſtly, this black clay is ſucceeded by a blue, ‘ which forms a ſtratum from five to ſix feet ‘ thick. In theſe different clays we find pyrites ‘ of a pale yellow colour, and of various fi‘gures. . . The water found below all theſe ‘ clays prevented us from penetrating any ‘ deeper.’

The ſtrata in the quarries of the diſtrict of Moxouris, above the ſuburb of Saint-Marceau, are diſpoſed in the following order.

Feet

	Feet.	Inches.
‘ 1. Vegetable ſoil	1	
‘ 2. Tufa	12	
‘ 3. Sand	18	
‘ 4. Yellowiſh earth	12	
‘ 5. Tripoli; that is, a white, fat, compact earth, which hardens when expoſed to the ſun, and marks any ſubſtance in the ſame manner as chalk	30	
‘ 6. Flints, or a mixture of greaſy ſand	12	
‘ 7. Rock	2	
‘ 8. A ſtratum of ſmall ſtones, from one to two feet	2	
‘ 9. Two ſtrata of ſtone, which diſſolves by the operation of the air and weather	1	
‘ 10. Earth and gravel	1	6
‘ 11. Free-ſtone	1	6
‘ 12. Very hard lime-ſtone	1	
‘ 13. A greeniſh ſtratum	1	6
‘ 14. A tender calcareous ſtone, which forms two ſtrata, one of 18 inches, and the other of two feet	3	6
‘ 15. Several ſmall beds of baſtard calcareous ſtone. They precede the ſheet of water common in pits. This ſheet the		

diggers

	Feet.
diggers are obliged to remove before they can obtain the potters clay, which lies between two waters *. In all	99

I have given this ſpecimen for want of a better; for the uncertainties with regard to the nature of the different ſtrata are apparent. We cannot, therefore, be too anxious in recommending to obſervers to be more exact in defining the nature of thoſe materials they attempt to deſcribe. They may at leaſt diſtinguiſh them into vitreſcent and calcareous, as in the following example.

The ſoil of Lorrain is divided into two great zones: The eaſtern, which covers the chain of *Voges*, which are primitive mountains, compoſed entirely of vitrifiable and cryſtalized matters, as granite, porphyry, jaſper, and quarts, diſpoſed in detached blocks or groups, and not in regular ſtrata or beds. In all this chain of mountains, there is not the ſmalleſt veſtige of any marine production; and the hills which proceed from them conſiſt of vitrifiable ſand. Where they terminate, and upon a continued bounding line of their deſcent, the other zone commences, which is totally calcareous, diſpoſed

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* Mem. de l'Acad. des Sciences, Année 1756.

ſed in horizontal beds, and replete, or rather completely formed, of ſea bodies *.

The banks and beds of the earth in Peru are perfectly horizontal, and correſpond ſometimes at a great diſtance in different mountains, moſt of which are two or three hundred fathoms high. They are in general inacceſſible, and often as perpendicular as walls, which gives us an opportunity of perceiving the extremities of their horizontal ſtrata. When any of them happens to be round and detached from others, each bed appears like a very flat cylinder, or a ſection of a cone of no great height. Theſe different beds, placed one above another, and diſtinguiſhed by their colour and various contours, often reſemble a regular and artificial ſtructure. In this country, we ſee the mountains perpetually aſſuming the appearance of ancient and ſumptuous palaces, of chapels, of caſtles, and of domes. They are ſometimes fortifications compoſed of long curtins, and defended with bulwarks. After examining theſe objects, and the correſpondence of their ſtrata, we can hardly entertain a doubt, that the circumjacent land has not, at ſome period, been really ſunk. It appears, that thoſe mountains, whoſe baſes were moſt ſolidly ſupported, remained as monuments to

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* Note communicated to M. de Buffon, par M. l'Abbé Bexon, March 15th 1777.

to indicate the height which the ſoil of theſe countries anciently poſſeſſed *.

The mountain of Birds, called in Arabic *Gebeliter*, is ſo equal from top to bottom, for the ſpace of half a league, that it rather reſembles a wall regularly built by the hands of man, than a rock formed in this manner by the operation of Nature. The Nile waſhes this mountain a long way; and it is diſtant from Cairo in Upper Egypt four and a half days journey †.

To theſe obſervations, I ſhall add a remark made by moſt travellers, that, in Arabia, the ſoil is of various natures. The region neareſt to Mount Libanus preſents nothing but broken and overturned rocks, and is called *Arabia Petrea.* The removal of the ſoil, by the movement of the waters, has rendered this country almoſt totally barren; whilſt the lighter mud, and all the good earth, have been carried to a greater diſtance, and depoſited in that part of the country called *Arabia Felix.* Beſides, the *revers* in Arabia Felix, as well as every where elſe, are more rugged toward the African ſea, *i. e.* to the weſt, than toward the Red ſea, which is on the eaſt.

II.

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* Bouguer, figure de la Terre, p. 89.

† Voyage du P. Vanſleb.

II.

Of the interior Rock of the Globe.

In p. 179. I remarked, that *ſolid rocks are often ſupported by beds of earth, clay, or ſand, which have much leſs ſpecific gravity. This is the caſe with moſt hills, and is eaſily perceived. But, in high mountains, the ſummits are not only rocks, but theſe rocks are ſupported by others; and this ſtructure runs through ſuch an extent of country, where one mountain riſes out of another, that it is difficult to determine whether they are founded on earth, or of what nature this earth is. I have ſeen rocks cut perpendicularly for ſome hundreds of feet; but theſe rocks reſted upon other rocks, without my being able to perceive where they ended. May we not, however, be allowed to conclude from the leſs to the greater? Since the rocks of ſmall mountains, the baſes of which are viſible, reſt upon earths leſs heavy and leſs ſolid than ſtone, is it not reaſonable to think, that earth is likewiſe the baſis of high mountains?*

I acknowledge that this conjecture, derived from analogy, is ſufficiently founded. The conjecture I then hazarded was written thirty-four years ago. Since that time, I have acquired ideas and collected facts which convince me, that the great mountains compoſed of vitreſcent materials, and produced by the action of the primitive fire, are connected immediately with the interior rock of the globe, which is alſo a vitreous rock of the ſame kind. Theſe great mountains are a part of this immenſe rock, and are only prolongations or eminences formed upon the ſurface of the globe at the time of its conſolidation. Hence we ought to regard them as conſtituent parts of the original maſs of the earth. But the hills or ſmaller mountains, which reſt upon clay or vitrifiable ſand, have been formed by the motion and ſediments of the waters, at a time long poſterior to the formation of the great mountains by the primitive fire *. It is in theſe points or projections which form the nucleus of mountains, that the veins of metals, though their height be conſiderable, are

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* The internal parts of the primitive mountains which I have penetrated, either in pits or in the galleries of mines, to the depth of twelve and fifteen hundred feet, are entirely compoſed of *pure* vitreous *rock*, in which there are ſlight and irregular fiſſures, through which the water iſſues, and vitriolic and metallic ſolutions. From this fact we may conclude, that the whole nucleus of theſe mountains is a pure rock, adhering to the primitive maſs of the globe. We indeed find, upon their ſides, and upon the margins of the valleys, maſſes of clayey earth, and banks of calcareous ſtones, at conſiderable depths. But theſe are only the remains of thoſe materials which filled up the cavities of the earth, and muſt be referred to the ſecond epoch of Nature; *Note communicated by M. de Grignon to M. de Buffon, Aug.* 6. 1777.

are not of the higheſt kind, but of a mean height, and uniformly arranged, *i. e.* they riſe by gradual elevations, and are connected with a conſiderable chain of mountains, which are occaſionally interrupted by valleys.

III.

Of the Vitrification of Calcareous Subſtances.

In page 184. I ſaid, that *calcareous bodies are alone incapable of being vitrified, and ſeem to form a diſtinct claſs. All other ſubſtances may be converted into glaſs.*

I had not then made thoſe experiments which have ſince convinced me, that calcareous ſubſtances, like all others, may be reduced to glaſs. To produce this effect, nothing more is neceſſary than a fire more violent than that of our common furnaces. I reduced lime-ſtone to glaſs by a good burning glaſs. Beſides, M. d'Arcet, an able chymiſt, melted calcareous ſpar, without the addition of any other matter, by means of a porcelain furnace belonging to M. le Compte de Lauragais. But theſe operations were performed ſeveral years after the publication of my *Theory of the earth.* I knew only that, in the iron furnaces, the light, white, ſpungy matter, ſimilar to pumice-ſtone, which iſſues from them when over-heated, is nothing but a vitreous ſubſtance, proceeding from the calcareous bodies thrown into the furnace to aſſiſt the fuſion of the iron-ore. The ſole difference between the vitrification of calcareous and vitreſcent ſubſtances is, that the latter are immediately vitrified by the action of a violent fire alone; but calcareous bodies, before they are vitrified, paſs through a ſtate of calcination, and form a line. But, like all other ſubſtances, they vitrify, even in our common furnaces, whenever they are mixed with vitreſcent matters, eſpecially with thoſe which, like the *aubuë*, or ſlimy earth, yield moſt eaſily to the fire. Hence we may ſafely conclude, that, in general, every material of which this globe is compoſed, may be reduced to its primitive ſtate of glaſs, if a ſufficient degree of heat is applied.

ADDITIONS to the article, Concerning Shells, and other Productions of the Sea, found in the interior parts of the Earth, Vol. I. p. 188.

I.

Of Foſſil and Petrified Shells.

FROM what I have written, p. 202. on the ſubject of the Italian letter, in which it is remarked by this author, that *the pilgrims brought from Syria, in the time of the Cruſades, thoſe ſhells peculiar to the Levant, which are now found petrified in France, in Italy, and in other parts of Chriſtendom,* I find that I have not treated M. de Voltaire with ſufficient reſpect. I acknowledge, that I ſhould rather have taken no notice of this opinion, than revived it with a jeſt, eſpecially as humour is not my talent, and as this is perhaps the only example of pleaſantry in all my works. M. de Voltaire is a man whoſe ſuperiority of genius merits * the higheſt regard. I was furniſhed with this letter at the very time I was correcting the ſheet which contains the paſſage in queſtion. I read part of it only, imagining it to be the production of ſome learned Italian, who, from mere hiſtorical knowledge, had followed his own prejudices, without conſulting Nature; and it was not till after my volume on the Theory of the Earth was printed, that I knew the letter was written by M. de Voltaire. I then ſincerely regretted the expreſſions I had uſed. This truth I thought it incumbent on me to make public, as well for the ſake of M. de Voltaire, as for my own and that of poſterity, to whom I would not leave a doubt of the high eſteem I have always had for a man of ſuch uncommon talents, and who has done ſo much honour to human nature and to the age in which he lived.

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* This apology was publiſhed in the year 1778.

As the authority of M. de Voltaire made an impreſſion upon ſome perſons, others have endeavoured to diſcover whether his objection, with regard to the ſhells found below ground, has any foundation. Upon this ſubject, I ſhall ſubjoin an extract of a memoir which was tranſmitted to me, and which appears to have been written with that intention.

In traverſing the different provinces of France, and even of Italy, 'I every where ſaw,' le P. Chabenat remarks, 'figured ſtones; and, in particular places, their number was ſo great, and 'they were arranged in ſuch a manner, that it 'was impoſſible not to be ſatisfied, that theſe parts 'of the earth had formerly been covered with 'the ſea. I ſaw ſhells of every kind, which were 'perfectly ſimilar both in figure and ſize to thoſe 'which now exiſt. This obſervation was ſuffi-

‘ cient to convince me, that all theſe indivduals ‘ were of different ages, but of the ſame ſpecies. ‘ I ſaw cornua ammonis from half an inch to ‘ near three feet in diameter. I ſaw cockles of all ‘ ſizes, as well as other bivalves and univalves. I ‘ likewiſe ſaw belemnites, ſea muſhrooms, &c.

‘ The form and number of theſe figured ſtones ‘ prove, in the moſt inconteſtible manner, that ‘ they were formerly animals which exiſted ‘ in the ocean. The ſhells with which the ‘ moulds are covered ſeem to remove every ‘ doubt upon this ſubject; for, in particular ſpecimens, it is equally luſtrous, freſh, and natu‘ral, as in the living animal. If ſeparated from ‘ the mould or nucleus, we could not believe ‘ that it was petrified. The ſame obſervation is ‘ applicable to many other figured ſtones found ‘ in that beautiful and extenſive plain, which ‘ ſtretches from Montauban to Toulouſe, and ‘ from Toulouſe to Alby, as well as to the circumjacent places. The whole of this vaſt plain ‘ is covered with vegetable ſoil from half a foot ‘ to two feet thick. Below the ſoil there is a bed ‘ of coarſe gravel about two feet in thickneſs. ‘ The gravel is ſucceeded by a bed of fine ſand, ‘ which is nearly of an equal thickneſs; and the ‘ rock lies immediately under this bed of ſand. I ‘ have repeatedly examined the gravel with the ‘ greateſt attention, and I found it interſperſed ‘ with an infinite number of figured ſtones of

‘ the ſame form, but of various ſizes. I likewiſe ‘ found a number of ſea hedge-hogs, and other ‘ ſtones of a regular figure, and perfectly ſimi- ‘ lar. All theſe facts announce, in language the ‘ moſt expreſſive, that this country, as well as ‘ many others, had formerly been the bottom of ‘ the ſea, which, by ſome ſudden revolution, had ‘ retired, and left its various productions behind. ‘ I ſhall, however, ſuſpend my judgment, on ‘ account of M. de Voltaire’s objections, to re- ‘ move which, experience and obſervation muſt ‘ be united.’

Le P. Chabenat next ſubjoins ſeveral experiments to prove, that the ſhells found in the earth are the ſame with thoſe which ſtill exiſt in the ſea. Theſe experiments I ſhall not relate, becauſe they contain nothing new; and every man is ſatisfied, that foſſil and marine ſhells are preciſely of the ſame nature. Le P. Chabenat concludes his Memoir with remarking, that ‘ all the ‘ ſhells found in the bowels of the earth are un- ‘ queſtionably real ſhells, and relicks of animals ‘ whoſe element is the ocean, which had former- ‘ ly covered theſe countries; and, conſequently, ‘ that the objections of M. de Voltaire are ill ‘ founded *.’

II.

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* Memoir manuſcrit ſur les pierres figurées, par le P. Chabenat. Mountauban, Oct. 8. 1773.

II.

Of the places where Shells are found, p. 204.

TO the enumeration I have given of the great quantities of ſhells found in all parts of the world, I might add many particular obſervations which have been communicated to me during theſe laſt thirty-four years. I have received letters from the American iſlands, by which I am aſſured, that, in almoſt all of them, ſhells are found, either petrified or in their natural ſtate, in the interior parts of the earth, and often below the firſt ſtratum or vegetable ſoil. In the Malouine iſlands, M. de Bougainville found ſtones which divided into thin plates or leaves, and upon which were impreſſions of foſſil ſhells, of a ſpecies unknown in theſe ſeas *. To the ſame purpoſe I have letters from ſeveral parts of India and of Africa. Don Ulloa informs us †, that, in that diſtrict of Chili which extends from Talca Guano to Conception, different kinds of ſhells are found in great numbers, and without any mixture of earth; and that theſe ſhells are uſed to make lime. He adds, that this peculiarity would not be ſo remarkable, if theſe ſhells were found only in low places which might be covered with the ſea. But what is ſingular, he remarks, that the ſame heaps of ſhells are found in the hills at the height of fifty fathoms above the level of the ſea. I relate this fact, not becauſe it is ſingular, but becauſe it correſponds with all the others, and is the only one known to me concerning foſſil ſhells in this part of the world, where I am perſuaded that petrified ſhells will be found as well as every where elſe, at heights much greater than fifty fathoms above the level of the ſea; for the ſame Don Ulloa has ſince found petrified ſhells in the mountains of Peru at the height of above 2000 fathoms; and, according to M. Kalm, ſhells are ſeen in North America upon the tops of ſeveral hills: He tells us, that he ſaw them on the ſummit of the Blue Mountains. They have alſo been found in the chalk quarries near Montreal, in certain ſtones near Lake Champlain in Canada *, and in the moſt northern regions of this New Continent; for the Greenlanders believe, that the world had been drowned by a deluge, and, in evidence of this event, they quote the ſhells and the bones of whales which cover the moſt elevated mountains of their country †.

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* Voyage autour du monde, tom. 1. p. 100.

† Tom. 3. p. 314. de ſon Voyage.

If from this we paſs to Siberia, we ſhall find the ſame proof, of the ancient abode of the

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* Mem. de l'Acad. des Sciences, année 1752, p. 194.

† Voyage de M. Crantz; *Hiſt. gen. des voyages, tom.* 19. *p.* 105.

ocean upon all our Continents. Near the mountain Jeniſeik, there are other mountains leſs elevated, upon the ſummits of which we find heaps of ſhells well preſerved both in figure and natural colours. Theſe ſhells are all empty, and ſome of them fall into powder as ſoon as they are touched. *The ſea of this country produces no ſhells ſimilar to thoſe found on the tops of mountains.* The largeſt of theſe ſhells exceed not an inch in breadth, and others are very ſmall *.

But I can exhibit facts which are ſtill more obvious. Every man, in his own province, has only to open his eyes, and he will ſee ſhells in all places where lime-ſtone is found, as alſo in moſt clays, though, in general, marine productions are more rare in clays than in calcareous ſubſtances.

In the territory of Dunkirk, on the top of the mountain of the Recollets, near that of Caſſel, and at 400 feet above the level of the ſea, there is a horizontal ſtratum of ſhells, which are ſo cloſely packed together that moſt of them are broken. Above this ſtratum, there is a bed of earth from ſeven to eight feet deep. Theſe ſhells are ſituated at the diſtance of ſix leagues from the ſea, and they are of the ſame ſpecies with thoſe found on its coaſt †.

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* Relation de Meſſ. Gmelin et Muller; *Hiſt. gen. des voyages, tom.* 18. *p.* 342.

† Mem. pour la ſubdelegation de Dunkerque, relativement à l'Hiſtoire naturelle de ce canton.

In Mount Gannelon, near Anet, and at ſome diſtance from Compiegne, there are ſeveral quarries of excellent lime-ſtone. Between the different ſtrata of the lime-ſtone we find gravel mixed with an infinite number of ſea-ſhells, or portions of ſhells, which are very light and friable. In the ſame place, there are common oyſter-ſhells in fine preſervation, and extend more than a league and a quarter in length. In one of theſe quarries, there are three ſtrata of ſhells in different ſtates. In two of theſe ſtrata, they are ſo much broke, that their ſpecies cannot be diſtinguiſhed: But, in the third, there are oyſters, which have ſuffered no alteration, but that of being exceſſively dried. The nature, figure, and enamel of the ſhells, are the ſame as in the live animals. Theſe ſhells have acquired a great lightneſs, and eaſily exfoliate. The lime-ſtone quarries are ſituated at the foot of the mountain, and have a ſmall declivity. In deſcending towards the plain, we find oyſters, which are neither dried nor have undergone any change, but have the ſame weight, and the ſame enamel with thoſe which are daily taken out of the ſea *.

In the neighbourhood of Paris, theſe marine ſhells are not leſs common. The marl pits of Bougival furniſh a kind of middle-ſized

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* Extrait d'une Lettre de M. Leſchevin à M. de Buffon; *Compiegnie, Oct.* 8, 1772.

ſized oyſters. They are not entire, but cut in different directions, and finely poliſhed. Near Belleville, where free-ſtone is quarried, we find a maſs of ſand in the earth, which contains branched bodies, which may have been corals or madrepores converted into ſtone. Theſe marine bodies are not in the ſand alone, but in the ſtones, which likewiſe contain ſhells of different kinds, as volutes, univalves, and bivalves *.

Switzerland is not leſs abundant in foſſil marine bodies than France and the other countries we have mentioned. In Mount Pilate, in the canton of Lucerne, we find petrified ſea-ſhells, and the bodies and relicks of fiſhes. In the ſame mountain, there are corals, and ſlates which eaſily exfoliate, and, between the leaves, a fiſh is generally found. Some years ago, the jaws, and even entire heads of fiſhes, together with their teeth, were diſcovered †.

M. Altman remarks, that, in one of the higheſt parts of the Alps, near Grindelvald, where the famous glaciers (Gletchers) are formed, there are fine marble quarries, which he has repreſented in one of the engravings of theſe mountains. The marble quarries are only a few paces diſtant from the glacier. The marble

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* Mem. de M. Guettard; *Acad. des Sciences, anneé* 1764, *p.* 492.

† Promenade au Mont Pilate; *Journal étranger, mois de Mars*, 1756.

ble is of various colours, as white, yellow, jaſper, red, and green. The marble is drawn on ſledges above the ſnow as far as Underſeen, where they are embarked to be carried to Berne by lake Thorne, and afterwards by the river Are *. Thus marble and calcareous ſtones are found, at great heights, in this part of the Alps.

M. Cappeler, in making reſearches on Mount Grimſel, one of the Alps, has remarked, that the hills and ſmaller mountains which limit the valleys, are moſtly compoſed of free-ſtone, of a grain more or leſs fine and cloſe. The tops of theſe mountains generally conſiſt of lime-ſtone, of various colours and hardneſs. The mountains more elevated than theſe calcareous rocks, are compoſed of granite and other ſtones, which appear to be of the nature of granite and of emery. It is in theſe granity ſtones that rock-cryſtal begins to be formed. But, in the lime-ſtone rocks below, we find nothing but ſpar and calcareous concretions. In general, it has been remarked, concerning ſhells of every kind, whether foſſil or petrified, that certain ſpecies are always found together, and that others are never met with in theſe places. The ſame thing happens in the ocean, where particular ſpecies of teſtaceous animals are conſtantly found together,

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* Eſſai de la deſcription des Alpes glaciales, par M. Altman.

ther, in the ſame manner as certain plants always grow together on the ſurface of the earth *.

It has been too generally believed, that, there are no ſhells, or other productions of the ſea, on the higheſt mountains. It is true, that there are ſeveral ſummits, and a great number of peaks, which are entirely compoſed of granite and vitrifiable rocks, and in which no mixture can be perceived. Theſe contain neither the moulds of ſhells, nor the relicks of any marine bodies. But there is a much greater number of mountains, and ſome of them very high, where theſe relicks are to be found. M. Coſta, profeſſor of anatomy and botany in the univerſity of Perpignan, in the year 1774, diſcovered, ſome fathoms below the top of Mount Nas, ſituated in the middle of the Spaniſh Cerdagne, and one of the moſt elevated parts of the Pyrennees, a great number of lenticular ſtones, *i. e.* blocks compoſed of lenticular ſtones, and theſe blocks were of different figures and different ſizes; the largeſt might weigh from forty to fifty pounds. He remarked, that the part of the mountain where theſe lenticular ſtones were found, ſeemed to have formerly ſunk; for, in this place, he ſaw an irregular, oblique depreſſion, very much inclined to the horizon; and one of its extremities reſpected the top, and the other the bottom of the mountain. He could not diſtinctly perceive the dimenſions of this depreſſion, becauſe moſt of it was covered with ſnow, though it was the month of Auguſt. The banks of rocks which ſurrounded theſe lenticular ſtones, as well as thoſe immediately below, are calcareous for more than a hundred fathoms. This Mount Nas, to judge of it by the eye, ſeems to be as high as Canigou, and preſents no veſtige of a volcano.

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* Lettres philoſophiques de M. Bourguet, *Biblioth. raiſonnée, mois d'Avril, Mai, et Juin,* 1730.

A thouſand other examples of marine ſhells, found in an infinity of places, as well in France as in different parts of Europe, might be given. But ſuch an enumeration of particular facts, which are already too much multiplied, would ſwell this work, without anſwering any uſeful purpoſe. From the whole, however, we cannot refrain from drawing this obvious concluſion, that all the inhabited parts of the earth have formerly, and during a very long courſe of time, been covered with the waters of the ocean.

I ſhall only remark, that theſe ſea-ſhells are found in different ſtates. Some of them are petrifactions, or ſtones moulded into the form of ſhells; and others are in the ſame ſtate as they ſtill exiſt in the ocean. The quantity of petrified ſhells, which are nothing but ſtones figured by ſhells, is infinitely greater than that of foſſil ſhells, and they are never found together,

ther, nor even in places contiguous; it is only in the neighbourhood, and ſome leagues diſtant from the ſea, that we find beds of ſhells in their natural ſtate, and theſe are commonly the ſame with thoſe which exiſt in the adjacent ſeas. Petrified ſhells, on the contrary, are found, almoſt every where, at great diſtances from the ſea, and on the higheſt hills, many ſpecies of which belong not to our ſeas, and ſeveral of them have no exiſting repreſentatives; ſuch as thoſe ancient ſpecies we formerly mentioned, which only exiſted when the globe was much warmer. Of more than a hundred ſpecies of cornua ammonis, remarks one of our learned Academicians, with which we are acquainted, and which are found in the environs of Paris, of Rouen, of Dive, of Langres, and of Lyons, as well as in the Cevernes, in Provence, in Poitou, in Britain, in Spain, and in other countries of Europe, there is but one ſpecies, called the *Nautilus papyraceus*, found in our ſeas, and five or ſix others produced in foreign ſeas *.

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* Mem. de l'Acad. des Sciences, anneé 1722, p. 242.

III.

Of thoſe great Volutes called Cornua Ammonis, and of ſome large bones of terreſtrial animals.

IN p. 211. I ſaid, *That many ſhell-fiſhes inhabit the deepeſt parts of the ocean, and are never thrown upon the coaſts; authors have, therefore, termed them* Pelaſgie, *to diſtinguiſh them from the other kinds, which they call* Littorales. *It is probable that the cornu ammonis, and ſome other ſpecies found only in a petrified ſtate, belong to the former, and that they have been impregnated with ſtony matter in the very places where they are diſcovered. It is alſo probable, that the ſpecie of ſome animals have been extinguiſhed, and that theſe ſhells may be ranked among this number. The extraordinary foſſil bones found in Siberia, in Canada, in Ireland, and ſeveral other places, ſeem to confirm this conjecture; for no animal has hitherto been diſcovered to whom bones of ſuch enormous ſize could poſſibly belong.*

Upon this paſſage I have to make two important remarks:

1. That theſe cornua ammonis, which are ſo different from each other both in figure and

ſize, ſeem to form rather a genus than a ſpecies in the claſs of ſhell animals, are really the relicks of ſo many ſpecies which have periſhed, and no longer ſubſiſt. I have ſeen ſome of them ſo ſmall, that they exceed not a line, and others ſo large that they were more than three feet in diameter. Obſervers worthy of credit have aſſured me, that that they have ſeen ſome ſtill larger, and particularly one of eight feet in diameter, and one foot thick. Theſe different cornua ammonis ſeem to form diſtinct ſpecies. Some of them are more or leſs fluted. They are all ſpiral; but they terminate differently, both at their centres and at their extremities. Theſe animals, formerly ſo numerous, are no longer found in any of our ſeas. They are known to us by their relicks only; and the immenſity of their number cannot be better repreſented than by an example which I have daily before my eyes. In the iron mine near Etivey, (three leagues from my forge of Buffon), which has been wrought 150 years, and has ſupplied the iron works of Aiſy during all that time, there are ſuch quantities of cornua ammonis, entire and in fragments, that the greateſt part of the ore ſeems to have been moulded in theſe ſhells. The mine of Conflans in Lorrain, which ſupplies the furnace of Saint Loup in Franche-comte, is likewiſe entirely compoſed of belemnites and cornua ammonis. Theſe laſt ferruginous ſhells are ſo different in ſize, that they weigh from a drachm to two hundred pounds *. Other places might be mentioned where they equally abound. In the ſame manner, we find belemnites, lenticular ſtones, and moulds of many other ſhells, which now no longer exiſt in any part of the ocean, though they are almoſt univerſally diffuſed over the ſurface of the earth. I am perſuaded that all theſe loſt ſpecies formerly ſubſiſted during the time that the temperature of the earth and waters was warmer than it is at preſent; and that, in proportion as the globe cools, other ſpecies, which now exiſt, will periſh like the former, for want of heat ſufficient to ſupport them.

2. That ſome of thoſe enormous bones, which I thought had belonged to unknown animals, whoſe ſpecies was ſuppoſed to be loſt, have, nevertheleſs, after the moſt accurate examination, appeared to belong to the elephant and hippopotamus, but to ſpecies of theſe animals much larger than thoſe which now exiſt. Of land-animals I know only one ſpecies which is loſt; and it is that of the animals whoſe grinding teeth, with their juſt dimenſions, are repreſented in plates I. II. III. The other large teeth and bones which I have collected belonged to the elephant and hippopotamus.

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* Mem. de phyſique de M. Grignon, p. 378.

ADDITIONS to the Article, Of the Inequalities of the ſurface of the Earth, Vol. I, p. 228.

I.

Of the height of Mountains.

WE remarked, p. 237. that *the higheſt mountains in the world are the Cordeliers of America, and eſpecially that part of them which lies under the Equator, or between the Tropics.* Our mathematicians who were ſent to Peru, as well as ſome other travellers, have meaſured the height of theſe mountains above the level of the South Sea. Some of them were meaſured geometrically, and others by the barometer, which, being ſubject to little variation in that climate, gives the heights nearly as exact as a geometrical meaſurement. The following are the reſults of their obſervations.

Heights of the moſt elevated mountains of the Province of Quito in Peru.

	Fathoms.
Cota-catché, to the north of Quito	2570
Cayambé-orçou, under the Equator	3030

Pitchincha,

	Fathoms.
Pitchincha, a volcano in 1539, 1577, and 1660	2430
Antiſana, a volcano in 1590	3020
Sinchoulogoa, a volcano in 1660	2570
Illinica, ſuppoſed to be a volcano	2717
Coto-paxi, a volcano in 1533, 1742, and 1744	2950
Chinboraço, a volcano; the date of its eruption unknown	3220
Cargavi-raſo, a volcano in 1698	2450
Tongouragoa, a volcano in 1641	2620
El-altan, one of the mountains called Coillanes	2730
Sanguaï, a volcano which has burnt ſince the year 1728	2680

By comparing the heights of the mountains of South America with thoſe of our Continent, we will perceive that, in general, they are one fourth part higher than the mountains of Europe, and that almoſt the whole of them have been and actually are volcano's. But even the higheſt mountains in the interior parts of Europe, Aſia, and Africa, have been extinguiſhed long beyond the record of hiſtory. It is true, that, in ſeveral of theſe laſt mountains, we evidently recogniſe the ancient exiſtence of volcano's, as well by the black and burnt ſides of precipices, as by the nature of the matters which ſurround them, and which extend along the ridges of the mountains. But, as theſe mountains are ſituated in the interior parts of Continents, and now very diſtant from the ſea, the action of the ſubterraneous fires, which cannot produce great effects but by the ſhock of water, ceaſed after the ſeas retired. It is for this reaſon, that, in the Cordeliers, whoſe roots may be ſaid to border upon the South Sea, moſt of the peaks are actual volcano's; whilſt the volcano's of Auvergne, Vivarais, Languedoc, Germany, Switzerland, &c. in Europe, and thoſe of Mount Ararat in Aſia, and of Mount Atlas in Africa, have long been abſolutely extinct.

The height at which vapours freeze is about 2400 fathoms in the Torrid Zone, and about 1500 in France. The tops of high mountains ſometimes ſurpaſs this line from 800 to 900 fathoms, and all this ſpace is covered with ſnow which never melts. The higheſt clouds riſe not above 300 or 400 fathoms above theſe mountains, and conſequently exceed the level of the ſea about 3600 fathoms. Hence, if the mountains were ſtill higher, we ſhould ſee, in the Torrid Zone, a belt of ſnow commencing at 2400 fathoms above the level of the ſea, and terminating at 3500 or 3600 fathoms, not on account of the ceſſation of the cold, which augments in proportion to the elevation, but becauſe the vapours would not riſe higher *.

M,

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* Mem. de l'Acad. des Sciences, année 1744.

M. de Keralio, a learned philoſopher, has collected the heights of the mountains in ſeveral countries, from the meaſurements of different perſons.

In Greece, M. Bernoulli determined the height of Mount Olympus to be 1017 fathoms. Hence the ſnow cannot lie upon it perpetually; neither can ſnow lie conſtantly on Pelion in Theſſaly, nor on Cathalylium and Cyllene; becauſe the height of theſe mountains does not riſe to the freezing degree. M. Bougner aſſigns 2500 fathoms as the height of the Peak of Teneriff, the top of which is always covered with ſnow. Mount Ætna, the Norwegian Mountains, the Hemus, the Athos, the Atlas, the Caucaſus, and ſeveral others, ſuch as Mounts Ararat, Taurus, and Libanus, are perpetually covered with ſnow, near their ſummits.

	Fathoms.
Pontoppidan informs us, that the higheſt mountains of Norway are	3000
Note. This meaſure, as well as the following, appears to be exaggerated.	
According to M. Brovallius, the higheſt mountains of Sweden are -	2333
The following, according to the Memoirs of the Academy of Sciences, are the higheſt mountains of France.	
Le Cantal - - -	984
Mount Ventoux - -	1036

	Fathoms.
Le Canigou of the Pyrennees	1441
Le Mouſſec	1253
Le Saint-Barthélemy	1184
The Mountain of Gold in Auvergne, an extinguiſhed volcano	1048
According to Mr Needham, the height of the mountains of Savoy are,	
The Convent of St Bernard	1241
The Rock to the ſouth of St Bernard	1274
Mount Serène	1282
L'Allée Blanche	1249
Mount Tournè	1683
According to M. Facio de Duiller, Mount Blanc, or the Curſed Mountain, is	2213

It is certain, that the chief mountains of Switzerland are higher than thoſe of France, Spain, Italy, and Germany. Several learned men have aſcertained the height of theſe mountains.

The greateſt part of theſe mountains, according to M. Mikhéli, as the Wetter-horn, the Schreck-horn, the Eigheſſ-Schneeberg, the Fiſher-horn, the Stroubel, the Fourke, the Loukmarier, the Criſpalt, the Mougle, the ridge of Baduts and Gottard, are from 2400 to 2750 fathoms above the level of the ſea. But theſe meaſures, I ſuſpect, are too high, eſpecially as they exceed, by one half, thoſe given by Caſſini, Scheuthzer, and Mariotte, which may be eſtimated too low, but not to this extent. My ſuſpicion is farther confirmed, by conſidering that, both in the cold and temperate regions, where the air is always troubled with ſtorms, the barometer is ſubject to ſo great variations, that its reſults cannot be truſted.

II.

Of the Direction of Mountains.

In vol. I. p. 240. I remarked, that *the direction of the great mountains of America is from north to ſouth, and that thoſe of the Old Continent run from weſt to eaſt.* This laſt aſſertion requires to be modified; for though, at firſt ſight, we may follow the mountains as far as China, by paſſing from the Pyrennees in Auvergne, to the Alps in Germany, and in Macedonia, to Caucaſus and other mountains of Aſia, as far as the Tartarian ſea; and though Mount Atlas, in the ſame manner, appears to traverſe the Continent of Africa from weſt to eaſt, the middle of this vaſt peninſula may ſtill conſiſt of a chain of high mountains ſtretching from Mount Atlas to the Mountains of the Moon, and from theſe to the Cape of Good Hope: In this view, the middle of the Continent of Africa may be conſidered as conſiſting of mountains which run from north to ſouth through its whole extent, like the mountains

tains of America. Thoſe parts of Mount Atlas which traverſe Africa from weſt to eaſt, ſhould be conſidered as branches only of the principal chain. The mountains of the Moon, which run from weſt to eaſt, may likewiſe be regarded as collateral branches; and, if there are no volcano's in this prodigious range of mountains, it may be owing to the vaſt diſtance of the ſea from the middle regions of Africa; whilſt, in America, the ſea is very near the foot of the high mountains, which, inſtead of occupying the middle of the peninſula of South America, are all ſituated to the weſt; and the extenſive low lands are entirely on the eaſt ſide.

The great chain of the Cordeliers are not the only mountains of America which run from north to ſouth. In the territory of Guiana, about one hundred and fifty leagues from Cayenne, there is a chain of pretty high mountains, which alſo extends from north to ſouth. On the Cayenne ſide, this chain is ſo ſteep, that theſe mountains are almoſt inacceſſible. This ſteepneſs ſeems to indicate, that, on the other ſide, the declivity is gentle, and conſiſts of fine land. The tradition of the country, accordingly, or rather the teſtimony of the Spaniards, is, that, beyond the mountains, there are populous nations of ſavages united into regular ſocieties. It is likewiſe ſaid, that there is a gold mine in theſe mountains, and a lake in which grains of gold are found: But this fact requires confirmation.

In Europe, the chain of mountains which begins in Spain, and paſſes through France, Germany, and Hungary, divides into two great branches, one of which extends into Aſia by the mountains of Macedonia, Caucaſus, &c. and the other branch ſtretches from Hungary into Poland and Ruſſia, and extends as far as the ſources of the Wolga and Boriſthenes; and, ſtretching ſtill farther, it joins another chain in Siberia, and terminates in the north ſea to the weſt of the river Oby. Theſe chains of mountains ought to be regarded as one continued ridge, from which ſeveral large rivers derive their ſources: Some of theſe rivers, as the Tagus, and the Doura in Spain, the Garonne and the Loire in France, and the Rhine in Germany, empty themſelves into the ocean; others, as the Oder, the Viſtula, and the Niemen, fall into the Baltic ſea; others, as the Dwina, fall into the White ſea, and the river Petzora empties itſelf into the Frozen ſea. On the eaſt ſide, this chain of mountains gives riſe to the Yeucar and Ebre in Spain, to the Rhone in France, and to the Po in Italy, which fall into the Mediterranean; to the Danube and Don, which loſe themſelves in the Black Sea; and, laſtly, to the Wolga, which falls into the Caſpian.

Norway is full of rocks and groups of mountains. There are plains, however, which extend, without interruption, ſix, eight, and ten miles. Their direction is not from weſt to eaſt, like that of the other European mountains. On the contrary, they ſtretch, like the Cordeliers, from ſouth to north *.

In the ſouth of Aſia, from the iſland of Ceylon to Cape Comorin, there is a chain of mountains which ſeparates Malabar from Coromandel, traverſes the Mogul country, joins Mount Caucaſus, ſtretches through the country of the Calmucks, and terminates in the North Sea to the eaſt of the Irtis. Another chain extends from north to ſouth as far as Razatgat in Arabia, and may be traced, at ſome diſtance from the Dead Sea, as far as Jeruſalem: It ſurrounds the extremity of the Mediterranean, and the point of the Black Sea, from which it traverſes Ruſſia, and terminates in the North Sea.

We may likewiſe remark, that the mountains of Indoſtan and thoſe of Siam run from ſouth to north, and both unite with the rocks of Thibet and Tartary. Each ſide of theſe mountains preſents a different ſeaſon: On the weſt, they have ſix months of rain, while, on the eaſt, they enjoy the fineſt weather †.

All

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* Hiſt. Nat. de Norwege, par Pontoppidan. *Journal étranger, mois d'Aout*, 1755.

† Hiſt. Phil. et Polit. tom. 2. p. 46.

All the mountains of Switzerland, as thoſe of the Valleſe and the Griſons, thoſe of Savoy, Piedmont, and Tirol, form a chain, which extends, from north to ſouth, as far as the Mediterranean. Mount Pelate, which is ſituated in the centre of Lucerne, nearly in the centre of Switzerland, forms a chain of about fourteen leagues, extending from north to ſouth as far as the canton of Bern.

We may, therefore, conclude in general, that the greateſt eminences of this globe are ſituated from north to ſouth, and that thoſe which run in other directions ought to be regarded as collateral branches only of theſe primitive mountains: And, it is partly by this diſpoſition of the primitive mountains, that all the points or terminations of continents are either ſouth or north; as appears from the points of Africa, of America, of California, of Groenland, of Cape Comorin, of Sumatra, of New Holland, &c. This fact ſeems to prove, as formerly remarked, that the waters have proceeded in greater quantities from the ſouth than from the north pole.

If we conſult a new map of the world, in which are repreſented, round the Arctic Pole, all the lands of the four quarters of the globe, except the north point of America, and, round the Antarctic Pole, all the ſeas, and the ſmall portions of land to be found in the ſouthern hemiſphere, we ſhall evidently perceive, that many more revolutions have happened in the latter than in the former hemiſphere, and that the quantity of water has always been, and ſtill is, much greater there than in our hemiſphere. Every thing concurs in proving, that the greateſt inequalities of the globe exiſt in the ſouthern regions, and that the general direction of the primitive mountains is from north to ſouth, rather than from eaſt to weſt, through the whole extent of the earth's ſurface.

III.

Of the formation of Mountains.

ALL the valleys and dales on the ſurface of the globe, as well as all the mountains and hills, have originated from two cauſes, namely, fire and water. When the earth firſt aſſumed its conſiſtence, a number of inequalities took place on its ſurface; ſwellings and bliſters aroſe, as happens in a block of glaſs or of melted metal. Hence this firſt cauſe produced the original and the higheſt mountains, which reſt on the interior rock of the earth as their baſe, and below which, as every where elſe, there muſt have been vaſt caverns, which ſunk in at different periods. But, without conſidering this ſecond event, the falling in of the caverns, it is certain, that, when the earth firſt conſolidated, it was every where furrowed with depths and eminences, which were produced ſolely by the action of cooling. Afterwards, when the waters were precipitated from the atmoſphere, which happened when the earth cooled ſo much as to be unable to repel the vapours, theſe waters covered the whole ſurface of the globe to the height of two thouſand fathoms ; and, during their long abode upon our continents, the motion of the tides and that of the currents, changed the diſpoſition of the primitive mountains and valleys. Theſe movements would form hills in the valleys, and would cover the bottoms and knaps of the mountains with new beds of earth ; and the currents would produce furrows or valleys with correſponding angles. It is to theſe two cauſes, of which the one is much more ancient than the other, that the preſent external form of the ſurface of the earth is to be referred. Afterwards, when the ſeas ſunk down, they produced thoſe ſteep precipices on the weſt, where they ran with the greateſt rapidity, and left gentle declivities on the eaſt.

The ſtructure of thoſe eminences which were formed by the ſediments of the ocean, is very different from that of thoſe which owe their origin to the primitive fire. The firſt are diſpoſed in horizontal beds, and contain an infinite number of marine productions. The ſecond, on the contrary, are leſs regular in their ſtructure, and include no marks of ſea-bodies. Theſe mountains of the firſt and ſecond formation, have nothing in common but the perpendicular fiſſures; but theſe fiſſures are effected by two different cauſes. The vitreſcent matters, in cooling, diminiſhed in ſize, and, of courſe, they ſplit, and receded to different diſtances. But thoſe compoſed of calcarious matters tranſported by the waters, ſplit into fiſſures ſolely by drying.

I have often remarked, that, in detached hills, the firſt effect of the rains is gradually to carry down from the ſummit the earth and other bodies, which form at the foot a pretty thick ſtratum of good ſoil, while the top is left entirely bare. This effect is, and neceſſarily muſt be, produced by the rains. But a previous cauſe diſpoſed theſe and ſimilar matters round all hills, not excepting thoſe which are detached; for, on one ſide, the earth is uniformly better than on the other: The hills are always ſteep and precipitant on one ſide, and have a gentle declivity on the other; which proves clearly that the action, as well as the direction of the motion of the waters, were greater on one ſide than on the other.

IV.

IV.

Of the Denſity which certain matters acquire by Fire, as well as by Water.

IN p. 246, I ſaid, *that the hard points found in free-ſtone conſiſted of metallic matter, which appeared to have been melted by a ſtrong fire.* This aſſertion ſeems to inſinuate that the great maſſes of free-ſtone have originated from the action of the primitive fire. I at firſt imagined that this matter owed its denſity and the adheſion of its particles ſolely to the intervention of water. But I have ſince learned that the action of fire produces the ſame effect; and I ſhall relate ſome experiments which at firſt ſurpriſed me, but which I have repeated ſo often as to remove every doubt upon this ſubject.

EXPERIMENTS.

I pounded free-ſtones of different degrees of hardneſs, till they were reduced to a powder more or leſs fine. Theſe powders I employed to cover the cements I uſed in converting iron into ſteel. This powder of free-ſtone was ſtrewed over the cement, and heaped up, in the form of a dome of three or four inches in thickneſs, on an earthen veſſel of three feet long by two broad. After undergoing the action of the fire in my blaſt furnaces, during ſeveral days and nights without interruption, it was no longer the powder of free ſtone, but a maſs ſo ſolid that we were obliged to break it in order to uncover the veſſel which contained the iron, now converted into ſteel. The action of fire upon this powder of free-ſtone produced maſſes equally ſolid as free-ſtone of a middling quality, which does not ring under the hammer. This fact ſhowed that fire, as well as water, could prove a cement to vitrifiable ſand, and, conſequently, might have formed thoſe immenſe maſſes of free-ſtone which compoſe the nucleus of ſome of our mountains.

I am, therefore, fully perſuaded, that all the vitreſcent matters, of which the interior rock of the globe, as well as the nuclei of great mountains, are compoſed, have been produced by the action of the primitive fire; and that the waters have only formed thoſe acceſſory ſtrata which ſurround theſe nuclei, which are all parallel and horizontal, or equally inclined, and in which we find the relicks of ſhells and other productions of the ocean.

In the formation of free-ſtone and other vitreſcent matters, I pretend not to exclude the intervention of water. On the contrary, I am inclined to believe, that vitrifiable ſand may acquire conſiſtence, and unite into maſſes more or leſs hard, perhaps more eaſily by means of water than by the action of fire. I have related the above facts ſolely with the view of preventing objections which would not fail to be made, if it had been thought that I attributed the ſolidity of free-ſtones, and other bodies compoſed of vitrifiable ſand, to the intervention of water alone. It is certain, that all the free-ſtone found on the ſurface, or at inconſiderable depths, have been formed by water; for, on the ſurface of theſe maſſes of free-ſtone, we perceive marks of undulations and rollings, and ſometimes the impreſſions of plants and ſhells. But the free-ſtones formed by the ſediments of water are eaſily diſtinguiſhed from thoſe which have been produced by fire. The latter have a coarſer grain, and crumble down more eaſily than free-ſtone cemented by the intervention of water, which is more compact, and harder than that whoſe particles have been united by the action of fire.

Ferruginous matters aſſume a great degree of hardneſs by fire; for nothing is harder than caſt iron. But ferruginous bodies may likewiſe acquire conſiderable denſity by the intervention of water. Of this fact I was aſcertained by putting a quantity of filings of iron into veſſels expoſed to the rain. Theſe filings formed a maſs ſo hard, that it could only be broken by the hammer.

The vitreous rock which compoſes the interior maſs of the globe, is harder than common glaſs. But it is not harder than certain volcanic lavas, and much ſofter than caſt iron, which, however, is only glaſs mixed with ferruginous particles. This great hardneſs of the interior rock ſhows that it conſiſts of the moſt fixed particles of matter, and that, from the time of their conſolidation, they aſſumed the conſiſtence and hardneſs which they ſtill poſſeſs. Hence it cannot be objected to my hypotheſis of general vitrification, that bodies reduced to glaſs by our furnaces are leſs hard than the rock of the globe; ſince caſt iron, ſome lavas, or baſalts, and even certain porcelains, are harder than this rock, and yet they derive their hardneſs from the action of fire alone. Beſides, the elements of iron and other minerals which give hardneſs to matters liquified by fire, or attenuated by water, exiſted, as well as the fixed earth, from the time that the globe was firſt conſolidated: And I have already remarked, that the interior rock ought not to be regarded as pure glaſs, ſimilar to that we make with ſand and ſalts, but as a vitreous product mixed with matters the moſt fixed, and moſt capable of ſupporting the great and long continued action of the primitive fire, the great effects of which can only be compared in a very diſtant manner with the inconſiderable operations of our furnaces; and yet, from this compariſon, though unfavourable, we clearly perceive what effects are common to the primitive fire and to our furnaces; and it ſhows, at the ſame time, that the degree of hardneſs depends leſs on the degree of heat than on the combination of matters ſubmitted to its action.

V.

Of the inclination of the Strata in the Mountains.

I remarked, in Vol. I. p. 15. that, *in plains, the ſtrata are exactly horizontal. It is in the mountains anly that they are inclined to the horizon; becauſe they have originally been formed by ſediments depoſited upon an inclined baſe.*

The beds of calcarious matters are not only horizontal in the plains, but likewiſe in all mountains which have not been diſturbed by earthquakes or other accidental cauſes: And, when the ſtrata are inclined, the whole mountain is likewiſe inclined, and has been forced into that poſition by a ſubterraneous exploſion, or by the ſinking of a part of the earth, which had ſerved it as a baſis. We may therefore conclude, in general, that all ſtrata formed by the ſediments of water are horizontal, like the

water

water itſelf, except thoſe which have been formed on an inclined baſe, as is the caſe with the moſt part of coal-mines.

The moſt external part of the earth, whether in plains or mountains, is ſolely compoſed of vegetable earth, which owes its origin to ſediments of the air, of vapours, and of dews, and to the ſucceſſive deſtruction of herbs, leaves, and other parts of decompoſed plants. This firſt ſtratum every where follows the declivities and curvatures of the earth, and is more or leſs thick according to particular local circumſtances *. The vegetable ſtratum is commonly much thicker in valleys than on hills; and its formation is poſterior to that of the primitive ſtrata of the globe, the moſt ancient and moſt internal of which have been formed by fire, and the neweſt and moſt external have derived their origin from matters tranſported and depoſited in the form

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* On the tops of ſome mountains, the ſurface is abſolutely naked, and preſents nothing to the view but pure rock, or granite, without any vegetation, except in the ſmall fiſſures, where the wind has tranſported ſand, and collected the particles of earth which float in the air. At ſome diſtance from the laſt branch of the Nile, there is a mountain compoſed of granite, of porphyry, and of jaſper, which extends more than twenty leagues in length, by perhaps an equal number in breadth. The ſurface of the ſummit of this enormous quarry, we are aſſured, is abſolutely devoid of vegetables, and forms a vaſt deſert, where neither quadrupeds, nor birds, nor even inſects, can exiſt. But exceptions of this kind, which are particular and local, merit no conſideration.

form of ſediments by the motion of the waters. Theſe, in general, are horizontal; and it is only by the action of particular cauſes that they ſometimes appear inclined. The beds of calcarious ſtones are commonly horizontal, or ſlightly inclined; and, of all calcarious ſubſtances, the beds of chalk preſerve their horizontal poſition moſt exactly. As chalk is only the duſt of decayed calcarious bodies, it has been depoſited by waters whoſe movements were tranquil, and their oſcillations regular; whilſt the matters which were only broken into large maſſes, have been tranſported by currents, and depoſited by the removal of the waters; which is the reaſon why their ſtrata are not ſo perfectly horizontal as thoſe of chalk. The high coaſts of Normandy are compoſed of horizontal ſtrata of chalk ſo regularly perpendicular, that, at a diſtance, they have the appearance of fortified walls. Between the ſtrata of chalk there are ſmall beds of black flint, which give riſe to the black veins in white marble.

Beſide the calcarious ſhells, the ſtrata of which are ſlightly inclined, and whoſe poſition has never been changed, there are many others which have been deranged by different accidents, and which are all much inclined. Of theſe there are many examples in various parts of the Pyrennees, ſome of which are inclined forty-five, fifty, and even ſixty degrees below the horizontal line. This circumſtance ſeems to prove, that great changes have been produced in theſe mountains by the ſinking of ſubterraneous caverns which had formerly ſupported them.

VI.

Of the Peaks of Mountains.

I endeavoured to explain, Vol. I. p. 247. how the peaks of mountains had been deprived of the vitrifiable ſands with which they had been originally inveſted; and my explanation errs in this circumſtance only, that I attributed the firſt formation of the rocks which form the nuclei of theſe peaks to the intervention of water, inſtead of aſcribing it to the action of fire. Theſe peaks or horns of mountains are nothing but prolongations of the interior rock of the globe, which were environed with great quantities of ſcoriae and duſt of glaſs. Theſe looſe materials muſt have been carried down by the movement of the ſea, when it made its retreat. Afterwards, the rains and torrents of water would ſoon deprive the maſſes of pure rock of all their coverings, and make them completely bare, as they are at preſent. I may remark, in general, that no other change falls to be made in my theory of the earth than the following fact, that the firſt mountains derived their origin from the primitive fire, and not from the intervention of water, as I had conjectured; becauſe I had then been induced to believe, by the authority of Woodward and ſome other naturaliſts, that ſhells were found on the tops of all mountains. But, from more recent obſervations, it appears, that there are no ſhells on the higheſt ſummits, nor above two thouſand fathoms above the level of the ſea. Hence the waters have never ſurmounted thoſe high ſummits, or at leaſt have remained but a ſhort time upon them; ſo that they have formed only the hills and the calcarious mountains, which never riſe to the height of two thouſand fathoms.

ADDITIONS to the article, Of Rivers, Vol. I. p. 251.

I.

Additional Obſervations on the Theory of running Waters.

PAGE 266. Concerning the theory of running waters, I have to add a new obſervation which I made ſince I eſtabliſhed mills, by which the different celerities of water may be pretty accurately aſcertained. Theſe mills are compoſed of nine wheels, ſome of which are impelled by a fall of water of two or three feet, and others by a fall of five or ſix feet high: I was at firſt ſurpriſed to find, that all the wheels turned more quickly in the night than in the day, and that the difference was greater in proportion to the height and breadth of the column of water. For example, if the water falls ſix feet, the wheel will turn a tenth, and ſometimes a ninth quicker in the night than in the day; and, if the fall is leſs high, the difference of celerity will likewiſe be leſs; but it is always ſo ſenſible as to be eaſily recogniſed. I aſcertained this fact by placing white marks upon the wheels, and reckoning the number of revolutions in equal times, both during the day and the night; and I uniformly found, by a great number of obſervations, that the time when the wheels moved with the greateſt celerity was the coldeſt hour of the night, and that they moved ſloweſt when the heat of the day was greateſt. In the ſame manner, I afterwards found, that the celerity of all the wheels is greater in winter than in ſummer. Theſe facts, which have eſcaped the obſervation of philoſophers, are of importance in practice. The theory of them is extremely ſimple: This augmentation of celerity depends ſolely on the denſity of the water, which is increaſed by cold and diminiſhed by heat: And, as the ſame volume of water only can paſs by the trough, this volume, which is denſer in winter and during the night, than in ſummer or in the day, acts with more force on the wheel, and, of courſe, communicates to it a greater quantity of motion. Thus, *caeteris paribus*, there will be leſs loſs of water, if we ſtop the machines during the heat of the day, and work them during the night. By obſerving this method in my forges, its influence in the proceſs of making iron amounted to one twelfth part.

Another obſervation merits attention: Of two wheels, the one nearer the canal than the other, but perfectly equal in every other reſpect, and both moved by an equal quantity of water, the wheel neareſt the canal moves quicker than the one more remote, and to which the water cannot arrive till after it has run over a certain ſpace in the particular runner that terminates in this wheel. It is well known, that the friction of water on the ſides of a canal diminiſhes its celerity. But this circumſtance is not ſufficient to account for the conſiderable difference in the motion of theſe two wheels. It is owing, in the *firſt* place, to the water in this canal not being preſſed laterally, as it is when it enters by the trough of the canal, and to its ſtriking immediately the ladles of the wheel. *Secondly*, This inequality of motion, depending on the diſtance of the wheels from the canal, is likewiſe owing to the water, which paſſes through a trough, not being a column of equal dimenſions with the trough; for the water, in its paſſage, forms an irregular cone, which is depreſſed on the ſides in proportion to the breadth of the volume of water in the canal. If the ladles of the wheel are very near the trough, the water acts very near as high as the aperture of the trough: But, if the wheel is more diſtant from the canal, the water ſinks in the runner, and ſtrikes not the ladles of the wheel at the ſame height, nor with equal celerity, as in the firſt caſe. The union of theſe two cauſes produces that diminution of celerity in wheels which are diſtant from the canal.

II.

Of the ſaltneſs of the Sea, p. 275.

ON this ſubject there are two opinions, and both of them are partly true. Halley attributes the ſaltneſs of the ſea ſolely to the ſalts of the earth carried down by the rivers; and even ſuppoſes that the antiquity of the world may be diſcovered by the degree of ſaltneſs in the waters of the ocean. Leibnitz, on the contrary, believes, that the globe having been liquified by fire, the ſalts and other empyreumatic ſubſtances produced with the aqueous vapours a ſalt lixivium, and, conſequently, that the ſea received its ſaltneſs from the beginning. The opinions of theſe two great philoſophers, though oppoſite, ſhould be united, and may even coincide with my own. It is extremely probable, that, at the beginning, the action of fire combined with that of water diſſolved all the ſaline ſubſtances on the ſurface of the earth; and, of courſe, that the firſt degree of ſaltneſs in the ſea proceeded from the cauſe aſſigned by Leibnitz; but this prevents not the ſecond cauſe aſſigned by Halley from having conſiderable influence upon the actual degree of ſaltneſs in the ſea, which muſt always augment, becauſe the rivers inceſſantly carry down great quantities of fixed ſalts, which cannot be abſtracted by evaporation. They remain, therefore, mixed with the general maſs of waters, which are, in general, more ſalt in proportion to their diſtance from the mouths of rivers, and where the heat of the climate produces the greateſt evaporation. That the ſecond cauſe acts more powerfully than perhaps the firſt, is proved by this circumſtance, that all lakes from which rivers iſſue are not ſalt, but almoſt all thoſe which receive rivers and diſcharge none, are impregnated with ſalt. The Caſpian Sea, Lake Aral, the Dead Sea, &c. owe their ſaltneſs ſolely to the ſalts tranſported thither by the rivers, and which cannot be carried off by evaporation.

III.

Of perpendicular Cataracts.

IN p. 279. I remarked, that the cataract of Niagara in Canada was the moſt famous, and that it fell from a perpendicular height of 156 feet. I have ſince been informed [*], that there is a cataract in Europe, which falls from a height of 300 feet. It is that of *Terni*, a ſmall village on the road from Rome to Bologna. It is formed by the river Velino, which derives its ſource from the mountains of Abbruzzo. After paſſing by *Riette*, a village on the frontier of the kingdom of Naples, it falls into the Lac de Luco, which ſeems to be ſupplied by abundant ſources; for the river runs out of it with more force than it enters, and proceeds to the foot of the mountain *del Marmore*, from which it is precipitated by a fall of 300 feet. It is received by a kind of abyſs, from which it eſcapes with great tumultuouſneſs. The celerity of its fall breaks the water with ſuch force againſt the rocks and the bottom of the abyſs, that a humid vapour ariſes, in which many rainbows of various ſizes are formed by the rays of the ſun; and, when the ſouth wind blows, and drives this miſt againſt the mountain, inſtead of ſeveral ſmall rainbows, the whole caſcade is crowned with a very lagre one.

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[*] Note communicated to M. de Buffon by M. Freſnoye.

ADDITIONS and Corrections to the article, Of Seas and Lakes, Vol. I. p. 290.

I.

Of the Limits of the South Sea.

THE South Sea is much broader than the Atlantic, and appears to be bounded by two chains of mountains, which correſpond as far as the Equator. The firſt chain is compoſed of the mountains of California, of New Mexico, of the Iſthmus of Panama, of the Cordeliers, of Peru, of Chili, &c. The other chain ſtretches through Kamtſchatka, Yeſſo, and Japan, and extends as far as the Larron iſlands, and even the New Philippines. The direction of theſe chains of mountains, which appear to be the ancient limits of the Pacific Ocean, is preciſely from north to ſouth; ſo that the Old Continent was bounded on the eaſt by one of theſe chains of mountains, and the New Continent by the other. Their ſeparation happened at the period when the waters, proceeding from the ſouth pole, began to run betweeen theſe two chains of mountains, which ſeem to unite, or at leaſt to make a very near approach to each other towards the northern regions. This is not the only indication of the ancient union of the two continents on the north. This continuity of the two continents between Kamtſchatka and the moſt weſtern lands of America, ſeems now to be proved by the new diſcoveries of navigators, who have found, under the ſame parallel of latitude, a great number of iſlands lying ſo near each other, as to leave only ſmall intervals of ſea between the eaſt of Aſia and the weſt of America under the Polar Circle.

II.

Of double Currents in ſome parts of the Ocean, Vol. I. p. 313.

I HAD too generally and two poſitively aſſerted, that, in no part of the ſea, a ſuperior and inferior current are to be found.

I have ſince received information, which ſeems to prove, that this effect actually exiſts, and can even be demonſtrated, in certain parts of the ſea. On this ſubject, M. Deſlandes, an able navigator, obligingly communicated to me the following accurate remarks, in two letters, the one dated December 6. 1770, and the other November 5. 1773.

'In your *Theory of the Earth*, Art. XI. *Of* '*Seas and Lakes*, you ſay, that *a double current* '*has been alledged to run through the ſtraits of* '*Gibraltar; but that thoſe who ſupport this opi*'*nion have been deceived by the regorging of the* '*water near the ſhores, which often produces a* '*motion oppoſite to that of the principal current.*

'After reading this paſſage, I determined to 'tranſmit you my obſervations on the ſubject.

'Two months after my departure from 'France, I reconnoitered the land between 'Capes Gonſalvas and Saint Catharine. The 'force of the currents, the direction of which is 'to the north north-weſt, correſponding exactly 'with the ſituation of the lands, obliged me to 'caſt anchor. The general winds of this region 'blow from the ſouth ſouth-eaſt, ſouth ſouth-'weſt, and ſouth-weſt. I ſpent two months 'and a half in making fruitleſs attempts to 'change my ſituation, and to reach the coaſt of 'Loango, where I had ſome buſineſs to tranſact. 'During this time, I remarked, that the ſea de'ſcended in the above direction from half a 'league to a league in the hour, and that, at 'certain depths, the currents aſcended below 'with the ſame rapidity as they deſcended a'bove.

'I aſcertained the depth of theſe oppoſite currents in the following manner. Being moored in eight fathoms water, and the ſea extremely clear, I fixed a lead of thirty pounds weight to the end of a line. At about two fathoms from the lead, I tied a table napkin to the line by one of its corners, and allowed the lead to ſink in the water. As ſoon as the table napkin entered, it took the direction of the firſt current. Continuing to obſerve it, I made it deſcend. Whenever I perceived that the current diſcontinued, I ſtopped. It then floated indifferently around the line. In this place, therefore, the run was interrupted. I then ſunk the table napkin about a foot lower, and it aſſumed an oppoſite direction. By marking the line at the ſurface of the water, I found that the table napkin was at the depth of three fathoms; from which I concluded, after different examinations, that, of eight fathoms water, three ran north north-weſt, and five ran in the contrary direction of ſouth ſouth-eaſt.

'The ſame day, I repeated the experiment in fifty fathoms water, being then diſtant from the land ſix or ſeven leagues. I was ſurpriſed to find that the upper current was deeper in proportion to the depth of the bottom. Of fifty fathoms water, I reckoned that from twelve to fifteen ran in the firſt direction. This

‘ phaenomenon did not take place during the ‘ whole two months and a half that I remained ‘ on this coaſt, but nearly one month only, and ‘ at different times; during theſe interruptions ‘ the whole water ran into the gulf of Guiney.

‘ This oppoſition of currents ſuggeſted the ‘ idea of a machine, which, being ſunk as ‘ far as the inferior current, and preſenting a ‘ great ſurface, might force my veſſel againſt ‘ the ſuperior current, I made the experiment ‘ in miniature upon a boat; and I proceeded ‘ ſo far as to produce an equilibrium between ‘ the force of the ſuperior current, joined ‘ to that of the wind, upon the boat, and ‘ the force of the inferior current upon the machine. ‘ I had not an opportunity of making ‘ trials on a larger ſcale. What I have related, ‘ Sir, is a truth which may be confirmed by every ‘ navigator who has viſited theſe climates.

‘ I imagine that the winds, as well as the rivers, ‘ which diſcharge themſelves into the ſea ‘ along this coaſt, and carry great quantities of ‘ earth into the gulf of Guiney, are the principal ‘ cauſes of theſe effects. Beſides, the bottom ‘ of this gulf, which, by its declivity, obliges the ‘ tide to run retrograde whenever it arrives at a ‘ certain level, and is inceſſantly preſſed by freſh ‘ quantities, while the wind acts in a contrary ‘ direction upon the ſurface, and conſtrains part ‘ of the water to obſerve its ordinary courſe. ‘ This ſeems to be the more probable, becauſe 'the ſea enters from all quarters into this gulf, 'and iſſues only by revolutions which ſeldom 'happen. The moon has no apparent effect; 'for the ſame thing takes place during all its 'phaſes.

'I had occaſion to be ſtill farther convinced 'that the preſſure of the water, when it comes 'to its level, joined to the inclination of the bottom, are the ſole cauſes of this phaenomenon. 'I found, that theſe currents exiſt only in proportion to the ſmaller or greater declivity of 'the ſhores; and I have every reaſon to believe, 'that they are not perceived beyond twelve or 'fifteen leagues from land, which is the greateſt diſtance along the coaſt of Angola, where 'we can be certain of finding the bottom. . . . .

'The following circumſtances ſeem to prove, 'that ſimilar changes in the currents take place 'in the open ſea. I made one of my experiments at a mean depth, namely thirty-five fathoms. I found, at the depth of ſix or ſeven 'fathoms, that the courſe of the water ran 'north north-weſt. On ſinking two or three 'fathoms more, my line ſtretched to the weſt 'north-weſt. At three or four fathoms deeper, 'the courſe was weſt ſouth-weſt, then ſouth-weſt, and ſouth. Laſtly, at twenty-five and 'twenty-ſix fathoms, the courſe was ſouth 'ſouth-eaſt, and towards the bottom it was 'ſouth-eaſt and eaſt ſouth-eaſt. From theſe 'experiments I drew the following concluſions:

'That I might compare the ocean between Africa and America to a great river, the courſe of which is almoſt conſtantly directed to the north-weſt; that, as it runs along, it carries down ſand and mud, which it depoſits on its banks. Theſe banks are, of courſe, heightened, and neceſſarily raiſe the level of the water, and oblige it to run retrograde in proportion to the declivity of the ſhore. But, as the water is directed by a primitive impulſe, it cannot return in a ſtraight line: Obeying the original movement, and yielding reluctantly to the laſt obſtacle, it muſt neceſſarily deſcribe a curve of greater or ſmaller extent, till it meets the middle current with which it may partly unite, or which may ſerve it as a fulcrum, and give it a direction contrary to that impreſſed on it by the bottom. As the maſs of water is in perpetual motion, the water towards the bottom, being nearer the cauſe and more preſſed, muſt always undergo the firſt changes, and run in a direction contrary to the ſuperior current, while the ſame cauſe reaches not different heights. Theſe, Sir, are my ideas. I have frequently taken advantage of theſe inferior currents; by ſinking a machine to different depths, according to the number of fathoms water I happened to be in, I was enabled to ſail againſt the upper current. I found, that, in calm water, and with a ſurface 'three times larger than that part of the prow 'which is below the water, we could run from 'a third to half a league in the hour. Of this 'fact I was aſcertained by my latitude, by boats 'which I anchored, and from which I found 'myſelf at a great diſtance an hour afterward; 'and, laſtly, by the diſtance of certain points a'long the coaſts.'

Theſe obſervations of M. Deſlandes ſeem to be deciſive, and I accede to them with pleaſure. I cannot ſufficiently thank him for demonſtrating not only that my ideas on this ſubject were, in general, juſt, but that, in particular circumſtances, they were liable to exceptions. It is not leſs certain, however, that the ocean forced open the ſtrait of Gibraltar, and, conſequently, that the Mediterranean ſea received a great augmentation by this irruption. I reſted this opinion not only on the current of the ocean into the Mediterranean, but on the ſituation of the land and the correſpondence of the ſtrata on the oppoſite coaſts, which has often been remarked by intelligent navigators. 'The irruption which 'formed the Mediterranean is evident, as well 'as that of the Black Sea by the ſtrait of the 'Dardanelles, where the current is always vio'lent, and the correſpondence of the angles of 'the two coaſts ſtrongly marked, as well as the 'ſimilarity of the ſtrata, which are preciſely the 'ſame on the oppoſite ſides *.'

Beſides,

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* Part of a letter written to M. de Buffon in 1772.

Beſides, the idea of M. Deſlandes, who conſiders the ſea between Africa and America as a great river, the courſe of which is toward the north-weſt, agrees perfectly with what I advanced concerning the water's running in greater quantity from the ſouth than from the north pole.

III.

Of the Northern Parts of the Atlantic Ocean.

ON viewing the iſlands and gulfs, which are very numerous round Greenland, it is difficult, as navigators remark, not to ſuſpect that the ſea falls back from the Poles towards the Equator. What favours this conjecture, the tide riſes eighteen feet at Cape des Etats, and only eight feet in the bay of Diſko, *i. e.* at ten degrees of higher latitude*.

This obſervation, joined to that of the preceding article, ſeems ſtill farther to confirm the movement of the waters of the ocean from the ſouthern to the northern regions, where they are forced, by the reſiſtance of the lands, to regorge or flow back toward the ſouth.

In Hudſon's bay, veſſels have to preſerve themſelves from mountains of ice, which are ſaid to be from fifteen to eighteen hundred feet thick, and which, being formed by a ſucceſſion of long winters, in ſmall gulfs perpetually filled with ſnow, have been detached by the north-weſt winds, or by ſome other powerful cauſe.

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* Hiſt. gen. des voyages, tom. 19. p. 2.

The north-weſt wind, which prevails perpetually during winter, and often in ſummer, excites, in the ſame bay, dreadful tempeſts. Theſe are ſtill more to be apprehended, becauſe ſhoals are here very frequent. In the countries which bound this bay, the ſun never riſes nor ſets without a great cone of light. When this phaenomenon diſappears, it is ſucceeded by the aurora borealis. Here the heavens are ſeldom ſerene. In ſpring and autumn the air is generally replete with thick fogs; and, during winter, with an infinity of ſmall threads of ice, which are viſible to the eye. Though the ſummer heats are conſiderable during two months or ſix weeks, thunder and lightning are rare *.

The ſea along the coaſts of Norway, which are bordered with rocks, is commonly from a hundred to four hundred fathoms deep, and the water is leſs ſalt than in warmer climates. The number of oily fiſhes with which this ſea is filled, renders it ſo fat that it is almoſt inflammable.

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* Hiſt. Philoſ. et politique, tom. 6. p. 308. 309.

ble. The tide is here inconſiderable, the higheſt not riſing above eight feet *.

Some obſervations have lately been made upon the temperature of the land and water in the climates adjacent to the north Pole.

'In Greenland, the cold begins with the new 'year, and becomes ſo piercing in the months 'of February and March, that the ſtones ſplit, 'and the ſea ſmokes like a furnace, eſpecially in 'the bays. In the midſt of this thick fog, 'however, the froſt is not ſo intenſe, as when 'the ſky is unclouded; for, when we paſs from 'the land to that foggy atmoſphere which co'vers the ſurface and margins of the waters, 'we feel a milder air, though our hair and 'clothes are ſtiffened with hoar-froſt. This fog 'produces more chilblains than a dry cold; and, 'when it paſſes from the ſea to a colder atmoſ'phere, it inſtantly freezes, is diſperſed through 'the horizon by the wind, and produces a cold 'ſo intenſe that no perſon can go into the open 'air, without running the hazard of having his 'hands and feet entirely frozen. It is in this 'ſeaſon, that we ſee the water freeze on the fire 'before it boils. It is then that the winter 'paves a road of ice between iſlands, and in the 'bays and ſtraits.

'Autumn is the fineſt ſeaſon in Greenland. 'But

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* Pontoppidan's Nat. hiſt. of Norway; *journal étranger, Août* 1755.

'But its duration is ſhort, and frequently interrupted by cold froſty nights. It is alſo about 'this time, that, in an atmoſphere darkened 'with vapours, we ſee fogs which freeze and 'form a tiſſue on the ſea ſimilar to cobwebs; 'and, in the fields, the air is impregnated with lucid atoms, or ſharp icicles like ſmall needles.

'It has often been remarked, that the ſeaſons 'in Greenland aſſume a temperature oppoſite to 'that which prevails in the reſt of Europe. 'When the winter is rigorous in the temperate 'climates, it is mild in Greenland, and very 'ſevere in this northern region, when it is moderate in our countries. At the end of the 'year 1739, the winter was ſo mild in the bay 'of Diſko, that the gueeſe, in the month of January, paſſed from the temperate to the frozen zone in queſt of warmer air; and that, in '1740 no ice was ſeen at Diſko in the month 'of March; while, in Europe, the ice prevailed, without interruption, from October to 'May. . . . .

'In winter 1763, which was extremely cold 'over all Europe, the cold was ſo little felt in 'Greenland, that ſome ſummers have been leſs 'mild*.'

We are aſſured by voyagers, that, in the ſeas adjacent to Greenland, there are very high mountains of floating ice, and others which reſemble rafts of two hundred fathoms in length, by ſixty or eighty in breadth. But theſe boards of ice, which form immenſe plains upon the ſea, are ſeldom above nine or twelve feet thick. They ſeem to be formed immediately on the ſurface when the cold is greateſt. But the floating and very high maſſes come from the land, *i. e.* from the environs of mountains and coaſts, from which they have been detached and carried down to the ſea by the rivers. Theſe maſſes of ice bring along with them great quantities of wood, which are afterwards thrown by the ſea upon the eaſtern coaſts of Greenland. This wood, it appears, neither comes from Labrador nor Norway; becauſe the north-eaſt winds, which are very violent in theſe countries, would puſh back the trees, and the currents which run to the ſouth of Davis's ſtrait, and Hudſon's bay, would ſtop all that might come from America to the coaſts of Greenland.

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* Hiſt. gen. des voyages, tom. 19. p. 20. &c.

The ſea begins to carry boards of ice to Spitzbergen in the months of April and May. A great number come from Davis's ſtrait, part of them from Nova Zembla, and the greateſt number from the eaſt coaſt of Greenland, being tranſported from eaſt to weſt according to the general movement of the ocean.

The following facts and notices are to be found in the voyage of Captain Phipps. 'The 'idea of a paſſage to the Eaſt Indies by the

'North Pole was ſuggeſted as early as the year '1527, by Robert Thorne, merchant of Briſ- 'tol. . . . . No voyage, however, appears to have been undertaken to explore the circumpolar ſeas, till the year 1607, when 'Henry Hudſon was ſet forth, at the charge of certain worſhipful merchants of London, to diſcover a paſſage by the North Pole to Japan and China. '. . And this I can aſſure at this preſent, that 'between ſeventy-eight degrees and a half, and 'eighty-two degrees, by this way there is no 'paſſage.

'In 1609, a voyage was ſet forth by the 'Right Worſhipful Sir Thomas Smith to the 'ſouth part of Spitzbergen; and, when near 'Foreland, he ſent his mate aſhore; and ſpeaking of the account he gave at his return, ſays, 'Moreover, I was certified that all the ponds 'and lakes were unfrozen, they being freſh water; which putteth me in hope of a mild ſummer here, after ſo ſharp a beginning as I have 'had; and my opinion is ſuch, and I aſſure 'myſelf it is ſo, that a paſſage may be as ſoon 'attained this way by the Pole, as any unknown 'way whatſoever, by reaſon the ſun doth give 'a great heat in this climate, and the ice (I 'mean that freezeth here) is nothing ſo huge as 'I have ſeen in ſeventy-three degrees. . . . Several other voyagers have attempted to diſcover this paſſage, but without ſucceſs.'

On the fifth of July, Captain Phipps ſaw great quantities of floating ice about the 79° 34′ of latitude. The weather was foggy. The next day he continued his courſe as far as the 79° 59′ 39″ between Spitzbergen and the ice. On the 7th, he proceeded through the floating maſſes of ice in queſt of an open paſſage to the north by which he might gain an open ſea. But the ice to the north-north-weſt formed one continued maſs; and at 80° 36′ the ſea was entirely frozen; ſo that all the attempts of Captain Phipps to diſcover a paſſage proved abortive.' 'On the '12th of September, Dr Irvine tried the temperature of the ſea in a ſtate of great agitation, 'and found it conſiderably warmer than that of 'the atmoſphere. This obſervation is the more 'intereſting, as it agrees with a paſſage in Plu'tarch's Natural Queſtions, not (I believe) before 'taken notice of, or confirmed by experiment, 'in which he remarks, 'that the ſea becomes 'warmer by being agitated in waves. . . . Theſe 'gales are as common in the ſpring as in the au'tumn; there is every reaſon to ſuppoſe, there'fore, that at an early ſeaſon we ſhould have met 'with the ſame bad weather in going out as we 'did on our return.' And, as Captain Phipps departed from England in the end of May, he certainly took the ſeaſon moſt favourable to his expedition. . . . 'There was alſo moſt probabili'ty, if ever navigation ſhould be practicable to the

‘ Pole, of finding the ſea open to the northward ‘ after the ſolſtice; the ſun having then exerted ‘ the full influence of his rays, though there was ‘ enough of the ſummer ſtill remaining for the ‘ purpoſe of exploring the ſeas to the northward ‘ and weſtward of Spitzbergen.’

I agree entirely with this able navigator; and I ſuſpect that the expedition to the Pole cannot be renewed with ſucceſs, and that we can never reach beyond the 82d or 83d degree. We are aſſured that a veſſel from Whitby, in the year 1774, penetrated as far as the 80th degree, without ſeeing ice ſufficient to prevent ſailing ſtill farther. A Captain Robinſon is likewiſe quoted, from whoſe journal it appears that, in 1773, he arrived at the 81° 30′. Laſtly, a Dutch ſhip of war, ſent to protect the whale-fiſhers, is ſaid to have advanced, about fifty years ago, as far as the 88th degree. Dr Campbell, it is added, received this intelligence from a Dr *Daillie*, who was in the veſſel, and practiſed phyſic in London in the year 1745 *. This is probably the ſame navigator whom I formerly quoted under the name of Captain Mouton. But I am extremely ſuſpicious of the fact; and I am perſuaded, that we ſhall in vain attempt to reach beyond the 82d or 83d degree, and that, if a paſſage by the north is practicable, it can only be by the way of Hudſon's bay.

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* Gazette de Literature, Août 9. 1774, No. 61.

On this ſubject, the following paſſage of the learned and ingenious author of the hiſtory of the Two Indies merits attention, 'Hudſon's bay 'always has been, and is ſtill looked upon as the 'neareſt road from Europe to the Eaſt Indies, 'and to the richeſt parts of Aſia.

'Cabot was the firſt who entertained an idea 'of a north-weſt paſſage to the South-ſeas; but 'his diſcoveries ended at Newfoundland. After 'him followed a crowd of Engliſh navigators, 'many of whom had the honour of giving their 'names to ſavage coaſts which no mortal had e'ver viſited before. Theſe bold and memora'ble expeditions were more ſtriking than really 'uſeful. The moſt fortunate of them did not 'furniſh a ſingle idea relative to the object of 'purſuit. The Dutch, leſs frequent in their at'tempts, and who purſued them with leſs ar'dour, were of courſe not more ſucceſsful, and 'the whole began to be treated as a chimera, 'when the diſcovery of Hudſon's bay rekindled 'all the hopes that were nearly extinguiſhed.

'From this time the attempts were renewed 'with freſh ardour. Thoſe that had been made 'before in vain by the mother-country, whoſe 'attention was engroſſed by her own inteſtine 'commotions, were purſued by New England, 'whoſe ſituation was favourable to the enter'priſe. Still, however, for ſome time there 'were more voyages undertaken than diſcove-

‘ ries made. The nation was a long time kept ‘ in ſuſpenſe by the contradictory accounts recei‘ ved from the adventurers. While ſome main‘ tained the poſſibility, ſome the probability, ‘ and others aſſerted the certainty of the paſſage; ‘ the accounts they gave, inſtead of clearing up ‘ the point, involved it in ſtill greater darkneſs. ‘ Indeed, theſe accounts are ſo full of obſcurity ‘ and confuſion, they are ſilent upon ſo many ‘ important circumſtances, and they diſplay ſuch ‘ viſible marks of ignorance and want of vera‘ city, that, however impatient we may be of de‘ termining the queſtion, it is impoſſible to build ‘ any thing like a ſolid judgment upon teſtimo‘ nies ſo ſuſpicious. At length, the famous ‘ expedition of 1746 threw ſome kind of light ‘ upon a point which had remained enveloped in ‘ darkneſs for two centuries paſt. But upon ‘ what grounds have the later navigators enter‘ tained better hopes? What are the experiments ‘ on which they found their conjectures?

‘ Let us proceed to give an account of their ‘ arguments. There are three facts in natural ‘ hiſtory, which henceforward muſt be taken ‘ for granted. The firſt is, that the tides come ‘ from the ocean, and that they extend more ‘ or leſs into the other ſeas, in proportion as ‘ their channels communicate with the great ‘ reſervoir by larger or ſmaller openings; from ‘ whence it follows that this periodical motion

‘ is ſcarcely perceptible in the Mediterranean, in ‘ the Baltic, and other gulfs of the ſame nature. ‘ A ſecond matter of fact is, that the tides are ‘ much later and much weaker in places more ‘ remote from the ocean, than in thoſe which ‘ are nearer to it. The third fact is, that vio‘lent winds, which blow in a direction with the ‘ tides, make them riſe above their ordinary ‘ boundaries, and that thoſe which blow in a ‘ contrary direction retard their motion, at the ‘ ſame time that they diminiſh their ſwell.

‘ From theſe principles, it is moſt certain that, ‘ if Hudſon’s bay were no more than a gulf in‘cloſed between two continents, and had no ‘ communication but with the Atlantic, the tides ‘ in it would be very inconſiderable; they would ‘ be weaker in proportion as they were further ‘ removed from the ſource, and would be leſs ‘ ſtrong wherever they ran in a contrary direc‘tion to the wind. But it is proved by obſer‘vations made with the greateſt ſkill and preci‘ſion, that the tides are very high throughout ‘ the whole bay. It is certain that they are ‘ higher towards the bottom of the bay than e‘ven in the ſtrait itſelf, or at leaſt in the neigh‘bourhood of it. It is proved that even this ‘ height increaſes whenever the wind blows from ‘ a corner oppoſite to the ſtrait; it is, there‘fore, certain, that Hudſon’s bay has a com-

'munication with the ocean; beſide that which 'has been already found out.

'Thoſe who have endeavoured to explain 'theſe very ſtriking facts, by ſuppoſing a com'munication of Hudſon's with Baffin's bay, or 'with Davis's ſtraits, are evidently miſtaken. 'They would not ſcruple to reject this opinion, 'for which indeed there is no real foundation, 'if they only conſidered that the tides are much 'lower in Davis's ſtraits, and in Baffin's bay, 'than in Hudſon's.

'But if the tides in Hudſon's bay can come 'neither from the Atlantic ocean, nor from a'ny other northern ſea, in which they are con'ſtantly much weaker, it follows that they muſt 'have their origin in the South Sea. And this 'is ſtill further apparent from another leading 'fact, which is, that the higheſt tides ever 'obſerved upon theſe coaſts, are always occa'ſioned by the north-weſt winds, which blow 'directly againſt the mouth of the ſtrait.

'Having thus determined, as much as the na'ture of the ſubject will permit, the exiſtence 'of this paſſage ſo long and ſo vainly wiſhed-for, 'the next point is to find out in what part of 'the bay it is to be expected. From conſider'ing every circumſtance, we are induced to 'think that the attempts, which have been hi'therto made without either choice or method, 'ought to be directed towards Welcome bay, on

‘ the weſtern coaſt. Firſt, the bottom of the ſea ‘ is to be ſeen there at the depth of about eleven ‘ fathom, which is an evident ſign that the wa‘ter comes from ſome ocean, as ſuch a tranſpa‘rency could not exiſt in waters diſcharged from ‘ rivers, or in melted ſnow or rain. Secondly, ‘ the currents keep this place always free from ‘ ice, while all the reſt of the bay is covered ‘ with it; and their violence cannot be account‘ed for but by ſuppoſing them to come from ‘ ſome weſtern ſea. Laſtly, the whales, who ‘ towards the latter end of autumn always go in ‘ ſearch of the warmeſt climates, are found in ‘ great abundance in theſe parts towards the end ‘ of ſummer, which would ſeem to indicate that ‘ there is an outlet for them from thence to the ‘ ſouth ſeas, not to the northern ocean.

‘ It is probable that the paſſage is very ſhort. ‘ All the rivers that empty themſelves on the ‘ weſtern coaſt of Hudſon's bay are ſmall and ‘ ſlow, which ſeems to prove that they do not ‘ come from any diſtance; and that conſequent‘ly the lands which ſeparate the two ſeas are of ‘ a ſmall extent. This argument is ſtrengthened ‘ by the height and regularity of the tides. ‘ Wherever there is no other difference between ‘ the times of the ebb and flow, but that which ‘ is occaſioned by the retarded progreſſion of ‘ the moon in her return to the meridian, it is ‘ a certain ſign that the ocean from whence 'thoſe tides come is very near. If the paſſage 'is ſhort, and not very far to the north, as every thing ſeems to promiſe, we may alſo preſume that it is not very difficult. The rapidity of the currents obſervable in theſe latitudes, 'which prevents any flakes of ice from continuing there, cannot but give ſome weight to this 'conjecture.'

I believe, with this excellent writer, that if a practicable paſſage exiſts, it muſt be at the bottom of Hudſon's bay, and that all attempts by Baffin's bay will be fruitleſs, becauſe the climate is too cold, and its coaſts are always frozen, eſpecially towards the north. But the exiſtence of this paſſage is rendered ſtill more doubtful by the lands diſcovered, in 1741, by Bering and Tchirikow, under the ſame latitude with Hudſon's bay; for theſe lands ſeem to form a part of the great Continent of America, which appears to ſtretch under the ſame latitude as far as the Polar circle. Of courſe, the paſſage into the ſouth ſea can only be found about the 55th degree of north latitude.

IV.

Of the Caſpian Sea, Vol. I. p. 327.

TO what was advanced in order to prove,

that the Caſpian ſea is only a lake, and never had any communication with the ocean, I have to add the anſwers I received from the Academy of Peterſburg to ſome queries I tranſmitted them concerning this ſea.

'Auguſto 1748, October 5. &c. Cancellaria 'Academiæ Scientiarum mandavit, ut Aſtra-'chanenſis Gubernii Cancellaria reſponderet 'ad ſequentia. 1. Suntne vortices in mari 'Caſpico necne! 2. Quae genera piſcium 'illud inhabitant! Quomodo appellantur! 'Et an marini tantum aut et fluviatiles ibidem 'reperiantur! 3. Qualia genera concharum! 'Quae ſpecies oſtrearum et cancrorum occur-'runt! 4. Quae genera marinarum avium 'in ipſo mari aut circa illud verſantur! ad 'quae Aſtrachenſis Cancellaria d. 13. Mart. '1749, ſequentibus reſpondit.

'Ad 1. in mari Caſpico vortices occurunt 'nuſquam; hinc eſt quod nec in mappis marinis 'extant, nec ab ullo officialium rei navalis viſi 'eſſe perhibentur.

'Ad 2. piſces Caſpium mare inhabitant; A-'cipenſeres, Sturioli, Gmel, Siruli Cyprini 'clavati, Bramae, Percae, Cyprini ventre acuto, 'ignoti alibi piſces, tincae, ſalmones, qui, 'ut e mari fluvios intrare, ita et in mare e fluviis 'remeare ſolent;

'Ad 3. conchae in littoribus maris obviae 'quidem ſunt, ſed parvae, candidae, aut ex u-

‘ nâ parte rubrae. Cancri ad littora obſervantur ‘ magnitudine fluviatilibus ſimiles; oſtreae autem ‘ et capita Meduſae viſa ſunt nuſquam;

‘ Ad 4. aves marinae quae circa mare Caſ‘ pium verſantur ſunt anſeres vulgares et rubri, ‘ pelicani, cygni, anates rubrae et nigricantes, ‘ aquilae, corvi aquatici, grues, plateae, ardeae ‘ albae, cinereae, et nigricantes, ciconiae albae ‘ gruibus ſimiles, Karawaiki (igotum avis no‘ men) larorum variae ſpecies, ſturni nigri et ‘ lateribus albis inſtar picarum, phyſiani, anſeres ‘ parvi nigricantes, Tudaki (ignotum avis no‘ men) albo colore praediti.’

Theſe facts, which are both accurate and authentic, confirm my poſition, that the Caſpian ſea has no ſubterraneous communication with the ocean. They prove farther, that this ſea never formed a part of the ocean; for it contains neither oyſters nor any other ſea-ſhells, but ſuch ſpecies only as are found in rivers. We are, therefore, warranted to conclude, that this ſea is nothing but a great lake formed by the waters of rivers, ſince we find in it the ſame fiſhes and the ſame ſhells which inhabit the rivers, and none of thoſe which people the ocean, or the Mediterranean.

V.

Of the Salt Lakes of Aſia.

IN the country of the Uſian Tartars, ſo called becauſe they inhabit the banks of the river Uf, there are, M. Pallas remarks, lakes, the waters of which were formerly freſh, and are now ſalt. He makes the ſame remark concerning a lake near Miacs.

One of the lakes moſt famous for the quantity of ſalt extracted from it, is that near the banks of the river Iſel, called *Soratſchya.* The ſalt of it, in general, is bitter, and employed by the phyſicians as a good purgative. Two ounces of this ſalt makes a very ſtrong doſe. Near Kurtenegſch, the ſhoals are covered with a bitter ſalt, which riſes, like a field of ſnow, to the height of two inches. The lake Korjackof furniſhes annually three hundred thouſand cubic feet of ſalt *. Lake Jennu likewiſe furniſhes a great quantity.

In the voyages performed under the auſpices of the Academy of Peterſburg, mention is made of the ſalt lake of Jamuſcha in Siberia. This lake, which is nearly round, is only about nine leagues in circumference. Its margins are covered

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* The cubic foot weighs thirty-five pounds each of ſixteen ounces.

vered with ſalt, and the bottom is clothed with cryſtals of ſalt. The water is extremely ſalt; and, when the ſun ſhines, it appears reddiſh like the ſky in a fine morning. The ſalt is as white as ſnow, and forms itſelf into cubic cryſtals. The quantity of it is ſo immenſe, that a number of veſſels may, in a ſhort time, be loaded with it; and, after it has been removed, it is again replaced in five or ſix days. It is ſufficient to remark, that it ſupplies the provinces of Tobolſki and Jeniſeik, and that this lake could ſupply fifty provinces of ſimilar extent. The commerce of this, as well as of all other ſalt, is reſerved in the hands of the crown. This ſalt is exceedingly good. It ſurpaſſes all others in whiteneſs, and none is more proper for curing meat. In the ſouth of Aſia, there are likewiſe ſalt lakes, one near the Euphrates, and another in the neighbourhood of Barra. There are others, it is ſaid, near Haleb, and at Larneca in the iſland of Cyprus. This laſt borders upon the ſea. The ſalt valley of Barra, being at no great diſtance from the Euphrates, might be worked, if its waters were made to run into this river, and if the earth was good: But at preſent this earth yields a good ſalt for the kitchen, and even in ſuch quantity that the Bengal veſſels, when returning in ballaſt, take in loadings of this ſalt [*].

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[*] Deſcript. de l'Arabie, par M. Niebuhr, p. 2.

ADDITIONS and Corrections to the Article, Of Inequalities at the bottom of the Sea, and of Currents, Vol. I. p. 351.

I.

Of the Nature and Quality of the ſoil at the bottom of the Sea, p. 357.

M. l'Abbé Dicquemare, a learned natural philoſopher, has made ſome obſervations on this ſubject, which ſeem to accord with what I have advanced in my Theory of the Earth.

Converſations with pilates of all languages, the peruſal of charts and ſoundings both ancient and modern, the examination of ſuch bodies as attach themſelves to the plummet, the inſpection of coaſts, banks, and of the ſtrata which compoſe the interior parts of the earth, to a depth nearly equal to the length of our common plumb lines, ſome reflections which are moſt analogous to this ſubject ariſing from phyſics, coſmography, and natural hiſtory, have made me ſuſpect, nay, have even convinced me, ſays M. l' Abbé Dicquemare, 'that, in ſome 'places, there muſt be two different bottoms, 'the one often covering the other at intervals: 'The ancient and permanent, which may be 'called the general bottom, and the other acci-'dental or particular. The firſt, which ought to 'form the baſis of a general picture, is the ſoil 'of the baſin that contains the ſea. It is com-'poſed of the ſame ſtrata which we every 'where find in the bowels of the earth, ſuch as 'marl, ſtone, clay, ſand, ſhells, all diſpoſed ho-'rizontally, and of an equal thickneſs through 'a great extent. . . Here, we find a bottom 'of marl, there a bottom of clay, ſand, or rock. 'Laſtly, the number of general bottoms diſco-'verable by ſounding exceeds not ſix or ſeven 'ſpecies. The moſt extenſive and thickeſt of 'theſe ſtrata, being uncovered, or cut perpendi-'cularly, form great ſpaces in the ſea, where 'we ought to recogniſe the general bottom, in-'dependent of ſuch foreign ſubſtances as 'may be depoſited by currents or other cauſes. 'There are other permanent bottoms which 'we have not hitherto mentioned: Theſe are 'thoſe immenſe maſſes of madrepores and 'corals, which often cover a bottom of rock, 'and thoſe enormous and extended banks of 'ſhells, which a rapid multiplication, or other 'cauſes, have accumulated, and which occur in 'different places, as it were in colonies. One 'ſpecies occupies a certain extent; the ſucceed-

'ing ſpace is occupied by another ſpecies, in 'the ſame manner as has been remarked with 'regard to foſſil ſhells, in a great part of Europe, 'and perhaps every where elſe. It is by ob'ſervations on the interior parts of earth, 'and on ſuch places as the ſea leaves uncovered, 'where we always ſee particular ſpecies reign'ing over certain diſtricts, that we have been 'enabled to form ſome idea of the prodigious 'number of individuals, and of the thickneſs 'of the banks at the bottom of the ſea, of which 'we can only know the ſurface by our ſound'ings.

'The accidental or particular bottom is 'compoſed of immenſe numbers of the pric'kles of the ſea-archin; of fragments of ſhells, 'ſometimes corrupted; of cruſtaceous animals; 'of madrepores; of ſea plants; of pyrites; of 'granites rounded by friction; of pieces of mo'ther-of-pearl; of mica; perhaps of talc, to 'which different names are given according 'to their appearances; of entire ſhells, but in 'ſmall quantity, and ſeemingly diſperſed 'through no great extent; of ſmall flints, ſome 'cryſtals, coloured ſands, a light ſlime, &c. 'All theſe bodies, diſſeminated by the currents, 'the agitation of the waters, and partly proceed'ing from the rivers, from the ſinking of hills or 'high beaches, and other accidental cauſes, ſel'dom perfectly cover the general bottom, which

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'pears every inſtant, when we found often in the 'ſame regions. . . . I remarked, that, during 'near a century, a great part of the general 'bottoms of the gulf of Gaſcony and la Man-'cha, have ſuffered little or no change, which 'ſupports my opinion concerning the two 'bottoms *.'

II.

Of Currents in the Ocean, Vol. I. p. 365.

TO the enumeration of currents, we ſhall add the famous current of Moſckoe, Moſche, or Male, on the coaſt of Norway, of which a learned Swede has given the following deſcription.

'This current, which took its name from the 'rock of Moſchenſicle, ſituated betwen the two 'iſlands of Tofode and Woeroen, extends four 'miles from north to ſouth.

'It is extremely rapid, eſpecially between the 'rock of Moſche and the point of Lofoede. But, 'in proportion as it approaches the two iſles of 'Woeroen and Roeſt, its rapidity diminiſhes. 'It finiſhes its courſe from north to ſouth in ſix 'hours, and from ſouth to north in an equal 'time.

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* Journ. de phyſ. par M. Abbé Rozier, Dec. 1775, p. 438.

‘ This current is ſo rapid, that it produces a ‘ number of ſmall eddies, which the Norwegians ‘ call *gargamer*.

‘ Inſtead of following the courſe of the tides, ‘ it obſerves an oppoſite direction. When the ‘ waters of the ocean riſe, they proceed from ‘ ſouth to north, but the current then runs from ‘ north to ſouth. When the ſea retires, it goes ‘ from north to ſouth, but the current then runs ‘ from ſouth to north.

‘ It is remarkable, that, both in going and re‘turning, it does not deſcribe a ſtraight line, like ‘ other currents found in ſome ſtraits, where the ‘ waters of the ſea riſe and fall; but it moves in ‘ a circular direction.

‘ When the waters of the ſea have riſen one ‘ half, thoſe of the current run to the ſouth ſouth‘eaſt. In proportion as the ſea riſes, the current ‘ turns towards the ſouth; from thence it turns ‘ toward the ſouth-weſt, and from the ſouth-weſt ‘ to the weſt.

‘ When the tide is full, the current goes to‘ward the north-weſt, and then toward the ‘ north. About the middle of the reflux, the ‘ current recommences its courſe, after having ‘ been ſuſpended during ſome ſeconds.

‘ The principal phaenomenon is its return by ‘ the weſt from the ſouth ſouth-eaſt toward the ‘ north. If it did not come back by the ſame ‘ road, it would be difficult and almoſt impoſſible

‘ to ſail from the point of Lofoede to the two ‘ great iſlands of Woeroen and Roueſt. There ‘ are two pariſhes, which would neceſſarily be uninhabited, if the current obſerved not the courſe ‘ I have deſcribed. But, as it actually obſerves ‘ this courſe, thoſe who paſs from the point of ‘ Lofoede to the two iſlands, wait till the tide ‘ has riſen one half, becauſe the direction of the ‘ current is then to the weſt. When they want ‘ to return from theſe iſlands to the point of ‘ Lofoede, they wait till the tide be half ebb; ‘ becauſe the courſe of the current is then toward ‘ the Continent. This circumſtance renders the ‘ paſſage very eaſy. . . Now, there is no current ‘ without a declivity; and here the water riſes ‘ on one ſide and deſcends by the other. . . . . .

‘ To be convinced of this truth, we have only ‘ to conſider that there is a ſmall tongue of land ‘ in Norway which extends ſixteen miles into ‘ the ſea, from the point of Lofoede, which inclines more to the weſt, as far as that of Loddinge, which inclines more to the eaſt. This ‘ tongue of land is ſurrounded by the ſea; and, ‘ whether during the flux or reflux, the water ‘ is always ſtopt there; becauſe it can have no ‘ iſſue but through ſix ſmall ſtraits or paſſages ‘ which divide the tongue of land into an equal ‘ number of portions. Some of theſe exceed not ‘ half a quarter of a mile in breadth, and ſometimes not half ſo much. Hence they can con-

‘ tain only a ſmall quantity of water. Of courſe, ‘ when the ſea riſes, a great part of the water ‘ coming to the north is ſtopt to the ſouth of ‘ this tongue of land. The waters are, therefore, ‘ much more elevated toward the ſouth than to‘ward the north. When the ſea retires, and ‘ goes toward the ſouth, a great part of the wa‘ter, in the ſame manner, is arreſted to the ‘ north of this tongue of land, and, conſequently, ‘ is much higher towards the north than towards ‘ the ſouth.

‘ The waters thus interrupted ſometimes at ‘ the north and ſometimes at the ſouth, can find ‘ an iſſue only between the point of Lofoede ‘ and the iſland of Woeroen, and between this ‘ iſland and that of Roueſt.

‘ The declivity of the waters, when they de‘ſcend, produces the rapidity of the current; ‘ and, for the ſame reaſon, this rapidity is greateſt ‘ toward the point of Lofoede. As this point is ‘ neareſt the place where the waters are ſtopt, ‘ the rapidity there is likewiſe greateſt; and, in ‘ proportion as the waters of the current extend ‘ toward the iſlands of Woeroen and Roueſt, ‘ their celerity decreaſes.

‘ It is now eaſy to conceive why the current ‘ is always diametrically oppoſite to the motion ‘ of the ſea. Nothing oppoſes the common move‘ments of the waters, whether they riſe or fall. ‘ But the waters which are ſtopt above the point

‘ of Lofoede can neither move in a ſtraight ‘ line, nor beyond this point, while the ſea has ‘ not deſcended lower, and has not, in retiring, ‘ carried off the waters, which thoſe that are ‘ ſtopt above the point of Lofoede ought to re‑ ‘ place. . . . . .

‘ At the commencement of the flux and reflux, ‘ the waters of the ſea cannot turn back thoſe of ‘ the current; but, when they have riſen or ‘ fallen one half, they are then enabled to ‘ change the direction of the current. As it can‑ ‘ not then turn toward the eaſt, becauſe the water ‘ is always ſtable near the point of Lofoede, as ‘ formerly remarked, it muſt neceſſarily proceed ‘ toward the weſt, where the water is lower *.’ This explication ſeems to be comformable to the true principles of the theory of running waters.

We muſt ſtill add the deſcription of the famous current of Scylla and Charybdis, near the iſland of Sicily concerning which Mr Brydone has lately made ſome obſervations tending to prove that the violence and rapidity of its movements are much diminiſhed.

‘ It was almoſt a dead calm, our ſhip ſcarce ‘ moving half a mile in an hour, ſo that we had ‘ time to get a complete view of the famous rock ‘ of Scylla, on the Calabrian ſide, Cape Pylorus ‘ on the Sicilian, and the celebrated Straits of the

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* Deſcript. du courant de Moſckoe, &c. *Journal étranger*, *Fevrier* 1758, *p.* 25.

‘ the Faro that runs between them. Whilſt we ‘ were ſtill ſome miles diſtant from the entry of ‘ the Straits, we heard the roaring of the current, ‘ like the noiſe of ſome large impetuous river ‘ confined between narrow banks. This in‘ creaſed in proportion as we advanced, till we ‘ ſaw the water in many places raiſed to a conſi‘ derable height, and forming large eddies or ‘ whirlpools. The ſea in every other place was ‘ as ſmooth as glaſs. Our old pilot told us, that ‘ he had often ſeen ſhips caught in theſe eddies, ‘ and whirled about with great rapidity, without ‘ obeying the helm in the ſmalleſt degree. ‘ When the weather is calm, there is little danger; ‘ but when the waves meet with this violent ‘ current, it makes a dreadful ſea. He ſays, ‘ there were five ſhips wrecked in this ſpot laſt ‘ winter. We obſerved that the current ſet ex‘ actly for the rock of Scylla, and would infal‘ libly have carried any thing thrown into it a‘ gainſt that point; ſo that it was not without ‘ reaſon the ancients have painted it as an object ‘ of ſuch terror. It is about a mile from the ‘ entry of the Faro, and forms a ſmall promon‘ tory, which runs a little out to ſea, and meets ‘ the whole force of the waters, as they come ‘ out of the narroweſt part of the Straits. The ‘ head of this promontory is the famous Scylla. ‘ It muſt be owned that it does not altogether ‘ come up to the formidable deſcription that

‘ Homer gives of it; the reading of which (like ‘ that of Shakeſpear’s Cliff) almoſt makes one’s ‘ head giddy. Neither is the paſſage ſo wonderous narrow and difficult as he makes it. Indeed it is probable that the breadth of it is greatly increaſed ſince his time, by the violent impetuoſity of the current. And this violence, too, ‘ muſt have always diminiſhed, in proportion as ‘ the breadth of the channel increaſed. The ‘ rock is near 200 feet high. There is a kind of ‘ caſtle or fort built on its ſummit; and the ‘ town of Scylla, or Sciglio, containing three or ‘ four hundred inhabitants, ſtands on its ſouth ‘ ſide, and gives the title of prince to a Calabreſe ‘ family. We lay juſt oppoſite to Cape Pylorus ‘ where the light-houſe is now built. . . . . The ‘ mouth of the Straits, betwixt the promontories ‘ of Pylorus in Sicily, and the Coda de Volpe in ‘ Calabria, appears ſcarcely to be a mile. But ‘ the channel enlarges to four miles in breadth ‘ near Meſſina, which is twelve miles from the ‘ mouth of the Straits. . . The celebrated gulf ‘ or whirlpool of Charybdis lies near to the entry of the harbour of Meſſina, and often occaſions ſuch an inteſtine and irregular motion in ‘ the water, that the helm loſes moſt of its power, ‘ and ſhips have great difficulty to get in, even ‘ with the faireſt wind that can blow. . . . Ariſtotle gives a long and formidable deſcription ‘ of it in his 125th chapter, De Admirandis,

‘ which I find tranſlated in an old Sicilian book ‘ I have got here. It begins, “ Adeo profun- “ dum, horridumque ſpectaculum,” &c. but it is ‘ too long to tranſcribe. It is likewiſe deſcribed ‘ by Homer, 12th of the Odyſſey; Virgil, 3d ‘ Æneid; Lucretius, Ovid, Salluſt, Seneca, as ‘ alſo by many of the old Italian and Sicilian ‘ poets, who all ſpeak of it in terms of horror; ‘ and repreſent it as an object that inſpired terror, ‘ even when looked on at a diſtance. It certain- ‘ ly is not now ſo formidable; and very proba- ‘ bly, the violence of this motion, continued for ‘ ſo many ages, has by degrees worn ſmooth the ‘ rugged rocks, and jutting ſhelves, that may ‘ have intercepted and confined the waters. The ‘ breadth of the Straits too, in this place, I make ‘ no doubt is conſiderably enlarged. Indeed, ‘ from the nature of things it muſt be ſo; the ‘ perpetual friction occaſioned by the current ‘ muſt wear away the bank on each ſide, and ‘ enlarge the bed of the water.

‘ The veſſels in this paſſage were obliged to ‘ go as near as poſſible to the coaſt of Calabria, ‘ in order to avoid the ſuction occaſioned by the ‘ whirling of the waters in this vortex; by ‘ which means, when they came to the narroweſt ‘ and moſt rapid part of the Straits, betwixt ‘ Cape Pylorus and Scylla, they were in great ‘ danger of being carried upon that rock. From ‘ whence the proverb, ſtill applied to thoſe who,

‘ in attempting to avoid one evil, fall into another,

“ Incidit in Scyllam, cupiens vitare Carybdim.”

‘ Here another light-houſe is placed to warn ‘ ſailors of their approach to Charybdis, as that ‘ other on Cape Pylorus is intended to give them ‘ notice of Scylla *.’

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* Brydone's Tour, vol. 1. p. 40. &c.

ADDITIONS to the Article, Of Regular Winds, Vol. I. p. 367.

I.

Of Reflected Wind, p. 379.

I Shall here mention a fact which ſeems to have eſcaped the obſervation of natural philoſophers, though every man is in a condition to convince himſelf of its truth. The fact is that the reflected wind is more violent than the direct, and ſtill more ſo in proportion to the nearneſs of the obſtacle by which it is reflected. I have often made the experiment by approaching a tower, of near a hundred feet high, and ſituated at the north of my garden at Montbard. When a ſtrong ſouth wind blows, we are violently puſhed back, at the diſtance of thirty paces: After which, there is an interval for five or ſix paces, where the violence of the reflected wind ceaſes, and ſeems to be in equilibrium with the direct. The nearer we approach, the ſtrength of the reflected wind augments, and puſhes us back with much greater force than the direct wind puſhes us forward. The cauſe of this general effect, which may be perceived oppoſite to any high buildings, precipices, &c. it is not difficult to diſcover. The air in the direct wind acts only by its celerity and its common volume; but this volume or maſs is conſiderably augmented by the compreſſion it receives from the obſtacle by which it is reflected; and, as the quantity of every motion conſiſts of the celerity multiplied by the volume, this quantity is much greater after being compreſſed than before. It is a volume of common air which acts in the firſt caſe, and a volume of air of double or triple the denſity which acts in the ſecond.

II.

Of the ſtate of the Air at the top of high Mountains.

IT has been proved by a thouſand experiments, that the higher we riſe above the level of the ſea or of plains, the column of mercury in the barometer ſinks the lower; and, conſequently, that the weight of a column of air diminiſhes in proportion to the elevation of the place; and as air is an elaſtic and compreſſible fluid, philoſophers have unanimouſly concluded from theſe experiments, that the air is much more denſe and compreſſed in the plains, than on the tops of mountains. For example, if the barometer, which ſtands at 27 inches in the plain, falls, on the top of a mountain, to 18, a difference of one third of the whole weight of the column of air, we ſay, that, the compreſſion of this element being always proportioned to the incumbent weight, the air at the top of the mountain is, of courſe, one third leſs denſe than that in the plain, becauſe it is compreſſed by a weight one third leſs. But ſtrong reaſons concur in making me ſuſpect the truth of this concluſion, which has hitherto been regarded as natural, and perfectly legitimate.

Let us, for a moment, abſtract this compreſſibility of the air, which ſeveral cauſes may augment or diminiſh, deſtroy or compenſate: Let us ſuppoſe the air to be every where equally denſe; if its thickneſs exceeded not three leagues, it is certain, that, in mounting one league, the barometer, being loaded with one third leſs weight, would deſcend from 27 to 18 inches. Now the air though compreſſible, appears to me to be equally denſe at all heights; and this opinion I ſhall ſupport by the following facts and reaſonings.

1. The winds are equally ſtrong, and equally violent at the tops of the higheſt mountains

as in the loweſt valleys. With regard to this fact all obſervers are agreed. Now, if the denſity of the air were one third leſs, the action of the wind would neceſſarily be one third weaker, and all the winds at the height of a league would be only zephirs, which is abſolutely contradicted by uniform experience.

2. Eagles, and ſeveral other birds, not only fly to the topsof the higheſt mountains, but riſe to great heights above them. Now, I aſk if theſe animals could either fly, or even ſupport themſelves, in a fluid one third leſs denſe than common air, and if the weight of their bodies, notwithſtanding all their efforts, would not oblige them to ſink lower?

3. All obſervers, who have climbed to the tops of the higheſt mountains, agree that they reſpire as freely as in any other ſituation, and that the only inconveniency they feel ariſes from the cold, which augments in proportion to the elevation. Now, if the air was one third leſs denſe at the tops of mountains, the reſpiration of man, and of birds which mount ſtill higher, would not only be injured, but ſtopped, as actually happens to animals in an air pump when one fourth or one third of the air contained in the receiver is exhauſted.

4. As cold condenſes as much as heat rarefies the air, and as, in proportion to the elevation of mountains, the cold increaſes, does it

not follow, that the degrees of condenſation of the air correſpond to the degrees of cold? This condenſation may equal, and even ſurpaſs that of the air in plains, where the heat eſcaping from the internal parts of the earth is much greater than at the tops of mountains, which are the moſt advanced and coldeſt points on the ſurface of the globe. Hence this condenſation of the air by cold, in high regions of the atmoſphere, ſhould compenſate the diminution of denſity produced by a decreaſe of the incumbent weight; and, of courſe, the air ſhould be equally denſe on the cold ſummits of mountains as in the plains. I am even led to think, that the air is more denſe on the tops of mountains, becauſe there the winds ſeem to be more violent, and the birds which ſoar above the higheſt ſummits appear to ſupport themſelves in the air with more eaſe in proportion to the height they riſe.

I may, therefore, conclude, that the free air is nearly of equal denſity at all heights, and that the atmoſphere extends not ſo high as has been determined, by conſidering the air as an elaſtic maſs compreſſed by an incumbent weight. Thus the total thickneſs of the atmoſphere may not exceed three leagues, inſtead of from fifteen to twenty, as has been conjectured by philoſophers*.

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* Alhazen, from the duration of the twilights, pretended that

The firſt ſtratum of the atmoſphere is filled with vapours exhaled from the ſurface of the globe, both by its own heat and that of the ſun. In this ſtratum, which extends to the height of the clouds, the heat ariſing from exhalations produces and ſupports a rarefaction that forms an equipoiſe to the ſuperior air; ſo that the lower ſtratum of the atmoſphere is not ſo denſe as it ought to be in proportion to the preſſure it receives. But, at the height where this rarefaction ceaſes, the air undergoes all that condenſation which is produced by the cold of this region, where the heat ariſing from the earth is much diminiſhed; and this condenſation appears to be even greater than that which might be produced, by the weight of the ſuperior ſtrata, in the inferior regions, which are ſupported by rarefaction. This idea is ſtrengthened by another phaenomenon, which is

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the height of the atmoſphere is 44331 fathoms. Kepler, upon the ſame principle, makes it 41110 fathoms.

M. de la Hire, when treating of the horizontal refraction of 32 minutes, fixes the mean height of the atmoſphere at 34585 fathoms.

M. Mariotte, from his experiments on the compreſſibility of air, makes the height of the atmoſphere 30000 fathoms.

However, comprehending under the atmoſphere that part of the air only in which refractions take place, M. Bouguer aſcertains the height not to be above 5158 fathoms, i. e. two and a half or three leagues; and I believe that this reſult is more certain and better founded than any of the others.

is the condenſation and ſuſpenſion of the clouds in that elevated region where they are formed and ſupported. Beyond this middle region, where the cold and condenſation commence, the vapours riſe, but ceaſe to be viſible, except when a part of a cold ſtratum ſeems to be puſhed back toward the ſurface of the earth, and when the heat eſcaping from the earth being for ſome time extinguiſhed by rains, the vapours then collect and thicken around us in the form of miſts and fogs. Without theſe circumſtances, the vapours never become viſible till they arrive at that region where the cold condenſes them into clouds, and ſtops their further aſcenſion: Their gravity, which augments in proportion as they become more denſe, fixes them in an equipoiſe which they cannot ſurmount. We perceive that the clouds are generally higher in ſummer, and ſtill higher in warm climates. It is in this ſeaſon and in theſe climates that the ſtratum formed by evaporation from the earth riſes higheſt. On the contrary, in the frozen regions near the pole, where the evaporation produced by the heat of the globe is much leſs, the ſtratum of denſe air ſeems to touch the ſurface, and there to retain the clouds, which never riſe higher, but ſurround theſe gloomy regions with perpetual fogs.

III.

Of ſome Winds which have a regular variation.

THERE are certain climates and particular countries where the winds vary regularly; ſome at the end of ſix months, others in a few weeks, others from morning to night, and from night to morning. In Vol. I. p. 388. I remarked, That, *at St Domingo, there are two different winds which riſe regularly every day; the one, which is from the ſea, comes from the eaſt, and begins at* 10 *o'clock before noon; the other, which is a land-wind, riſes at* 6 *or* 7 *in the evening, and continues the whole night.* M. Freſnaye writes me, that my information has not been exact. 'The two 'regular winds,' he remarks, 'which blow at 'St Domingo, are both from the ſea, and blow, 'the one in the morning from the eaſt, and the 'other in the evening from the weſt, which is 'only the ſame wind returned. It is evidently 'occaſioned by the ſun; for, every man perceives 'that, between one and two o'clock after noon, 'a tranſient guſt ariſes. When the ſun de- 'clines, by rarefying the air on the weſt, it drives 'to the eaſt the clouds which the morning wind 'had confined toward the oppoſite quarter.

'Theſe returned clouds, from April or May till 'toward autumn, produce in the diſtrict of Port-'au-Prince the regular rains which conſtantly 'proceed from the eaſt. There is not a ſingle 'inhabitant who does not predict the evening 'rain between ſix and nine o'clock, when, accor-'ding to their mode of expreſſion, *the broken 'cloud has been ſent back.* The weſt wind con-'tinues not during the whole night. It falls 'regularly toward the evening; and, when it 'ceaſes, the clouds puſhed from the eaſt are en-'abled to fall in the form of rain, as ſoon as their 'weight exceeds that of an equal column of air. 'The wind which prevails in the night is a land-'wind, which proceeds neither from the eaſt 'nor the weſt, but follows the projections of 'the coaſt. At Port-au-Prince, the ſouth wind, 'becauſe it traverſes the courſe of the river, is 'intolerably cold during the months of January 'and February *.'

IV.

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* Note communicated to M. de Buffon by M. Freſnaye, one of the counſellors of St Domingo, dated March 10. 1777

IV.

Of Lavanges, or great maſſes of Snow and Ice rolling down from high mountains.

IN high mountains, there are winds produced by accidental cauſes, and particularly by *lavanges* *. In the environs of the Alpine glacieres, ſeveral ſpecies of *lavanges* are diſtinguiſhable; ſome of them are called *windy lavanges*, becauſe they produce a great wind. They are formed when a new fall of ſnow has been put in motion, either from melting below by the interior heat of the earth, or by the agitation of the air. The ſnow then forms itſelf into balls, and in rolling accumulates, falls in vaſt maſſes into the valleys, and produces a great agitation in the air; becauſe the ſnow runs with rapidity, and in immenſe volumes, and the winds occaſioned by the motion of theſe maſſes are ſo impetuous, that they overturn every thing, even the largeſt pines, that oppoſe their paſſage. Theſe lavanges cover the whole territory over which they extend with a very fine ſnow; and this powdered ſnow riſes in the air at the caprice of the winds, *i. e.* without any fixed direction, which is extremely dangerous

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[*] I know no ſingle Engliſh word expreſſive of this idea, and therefore retain the French term.

dangerous to people in the fields; becauſe they know not to what ſide to run in order to protect themſelves; for, in a few ſeconds, they find themſelves ſurrounded, and often completely buried with the ſnow.

Another ſpecies of *lavanges*, ſtill more dangerous than the firſt, is called by the country people Schlaglawen, *i. e. daſhing* or *ſtriking lavanges*. They proceed not with ſuch rapidity as the firſt kind; but they overturn every thing in their way, and carry along with them great quantities of earth, ſtones, flints, and even entire trees; ſo that their paſſage from the mountain to the valley is a vaſt track of deſtruction and ruin. As they proceed with leſs rapidity than the *lavanges* compoſed of pure ſnow, they are more eaſily avoided. Their approach is announced at a diſtance; for they ſhake the mountains and the valleys by their motion and weight, and produce a noiſe equal to that of thunder.

Theſe tremendous effects may proceed from very ſlight cauſes: A ſmall quantity of ſnow falling from a tree or a rock, the ſound of bells, or the ſhock of a cannon or muſket, provided they detach ſome portions of ſnow from the ſummit, which form into balls, and increaſe in magnitude as they deſcend, will accumulate into a maſs as large as a ſmall mountain before they arrive at the valley.

The inhabitants of countries ſubject to *lavanges* have invented ſeveral precautions to prevent their deſtructive effects. They place their buildings oppoſite to ſmall eminences, which may break the force of the *lavanges*. They likewiſe make plantations of wood before their habitations. At Mount St Godard, there is a foreſt in a triangular form, the acute angle of which is directed towards the mountain, and ſeems to have been planted with a view to turn off the *lavanges* from the village of Urſeren and the buildings ſituated at the foot of the mountain; and every perſon is forbid, under the ſevereſt penalties, to injure the foreſt, which may be regarded as the ſafeguard of the village. With the ſame intention there are, in many places, walls erected with their acute angles turned toward the mountain. A wall of this kind may be ſeen at Davis, in the country of the Griſons, as alſo near the baths of Leuk or Louache in Valais. In the ſame country of the Griſons, and other places, there are, in the paſſages through the mountains, vaults at convenient diſtances, cut out of the rock on the ſide of the high-way, which ſerve paſſengers as places of refuge againſt the lavanges *.

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* Hiſt. Nat. Helvetique, par Scheuchzer, tom. I. p. 155.

ADDITIONS to the Article, Of Irregular Winds, Water-ſpouts, &c. Vol. I. p. 386.

I.

Of the Violence of the South Winds in ſome Northern Countries.

THE Ruſſian voyagers have remarked, that, in the entry to the territory of Milim, there is, on the left of the river Lena, a great plain entirely covered with overturned trees, and that all theſe trees lie in a direction from ſouth to north for an extent of ſeveral leagues; ſo that the whole diſtrict, formerly covered with trees, is now ſtrewed with dead trunks in the above direction from ſouth to north. This effect of the ſouth winds has likewiſe been obſerved in other northern regions.

In Greenland, and particularly in the autumn, the winds are ſo impetuous, that the houſes are often ſhaken to pieces, and the boats and tents carried up into the air. The Greenlanders even aſſure us, that, when they go out to ſecure their boats, they are obliged to creep on their bellies, leſt they ſhould become the ſport of the winds. The moſt violent tempeſts come from the ſouth, turn to the north, and then terminate in a calm. It is on theſe occaſions that the ice in the bays is raiſed from its bed, and diſperſed in ſmall portions over the ocean*.

II.

Of Water-Spouts.

M. de la Nux, whom I have often quoted, and who lived forty years in the iſle of Bourbon, has had an opportunity of ſeeing a great number of water-ſpouts, and he has communicated to me his obſervations, of which the following is an abridgement.

The water-ſpouts obſerved by M. de la Nux were formed, 1. In calm days, and in thoſe intervals when the wind paſſes from the ſouth to the north; though he ſaw one, which was formed previous to this paſſage of the wind from one quarter to another, and even in the current of a north wind, *i. e.* a pretty long time before this wind had ceaſed: The cloud from which this water-ſpout depended, and to which it was attached, was ſtill violently driven to the ſouth. The ſun, at the ſame time, was ſeen behind the cloud

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* Hiſt. gen. des Voyages, tom. 18. p. 22.

cloud to the ſouth. It happened on the 6th day of January, about eleven o'clock before noon.

2. Theſe water-ſpouts are formed during the day in detached clouds, apparently very thick, much longer than broad, and well defined below in the direction of the horizon: The under part of theſe clouds is always very black.

3. All theſe water-ſpouts at firſt appear under the form of inverted cones, whoſe baſes are more or leſs extenſive.

4. Several of thoſe water-ſpouts that appear under the figure of inverted cones, are ſometimes attached to the ſame cloud; ſome are never entirely completed; ſome are diſſipated at a ſmall diſtance from the cloud; and others deſcend apparently very near to the ſurface of the ſea, under the form of a long flat cone, which is narrow and pointed at the bottom. In the centre of this cone, and through its whole length, there is a whitiſh tranſparent canal, about one third of the diameter of the cone, the two ſides of which were very black, eſpecially on their firſt appearance.

Theſe water-ſpouts were obſerved from a point in the iſle of Bourbon elevated 150 fathoms above the level of the ſea, and they were generally three, four, or five leagues from the place of obſervation, which was the houſe of M. de la Nux.

The following is a more particular deſcription of theſe water-ſpouts.

When the end of the ſhaft, or top of the cone, which is then very ſharp pointed, has deſcended about a fourth of the diſtance of the cloud from the ſea, we begin to perceive on its ſurface, which is commonly calm and of a tranſparent whiteneſs, a ſmall black circle, which is produced by the agitation and whirling of the water: In proportion as the point of this ſhaft deſcends, the water boils; this boiling increaſes in proportion as the point approaches toward the ſurface, and the water of the ſea riſes in ſucceſſive whirlings to a greater or ſmaller height, which, in the largeſt water ſpouts, is about twenty-feet. The end of the ſhaft is always above this whirling, the ſize of which is proportioned to that of the water ſpout which puts it in motion. The end of the ſhaft ſeems not to touch the ſurface of the ſea, otherwiſe than by joining itſelf to the boiling or whirling which riſes to meet it.

We ſometimes ſee larger and ſmaller cones of water-ſpouts proceeding from the ſame cloud; ſome of them have the appearance of threads, and others are much larger. We often ſee ten or a dozen of ſmall but complete water-ſpouts iſſuing from the ſame cloud, moſt of which are diſſipated near their exit, and viſibly aſcend to the cloud. In this laſt caſe, the ſhaft ſuddenly ſwells as far as the inferior extremity, and appears like a cylinder ſuſpended from the cloud, torn in pieces below, and of a ſmall extent.

The water-ſpouts with broad baſes gradually enlarge through their whole extent, and likewiſe in the under end, which ſeems to recede from the ſea and to approach the cloud. The agitation and whirling they produce in the water gradually diminiſhes, and the under part of the ſhaft ſoon enlarges and aſſumes nearly a cylindrical form. It is in this ſtate that the two ſides of the canal widen; and we then ſee the water ruſhing with rapidity, and in a ſpiral form, into the cloud. Laſtly, the appearance of the water-ſpout terminates by the ſucceſſive ſhortening of this ſpecies of cylinder.

The largeſt water-ſpouts remain longeſt without diſſipating; and ſome of them continue more than half an hour.

A torrent of rain generally ruſhes out of the ſame part of the cloud from which the water-ſpouts iſſue, and ſome of them not unfrequently ſtill adhere to the cloud; theſe torrents of rain often conceal water-ſpouts before they are diſſipated. I perceived diſtinctly, M. de la Nux remarks, on the 26th of October 1755, a water-ſpout in the middle of one of theſe torrents, which became ſo great that it was ſoon concealed from my view.

The wind, or the agitation of the air below the cloud, breaks neither the large nor the ſmall water-ſpouts; for this impulſion only declines them from the perpendicular. The ſmalleſt kinds form very remarkable curves, and even ſinuoſities. The extremity which terminates in the ſea is often far removed from the direction of the other which is attached to the cloud.

We never ſee new water-ſpouts formed after rain has fallen from the clouds which produced them.

'On the 14th day of June 1756, about four 'o'clock afternoon, I was,' ſays M. de la Nux, 'on the margin of the ſea, and above its level 'twenty or twenty-five feet. I ſaw twelve or 'fourteen water-ſpouts iſſue from the ſame 'cloud. Three of them only were conſiderable, 'and particularly the laſt. The canal in the 'middle of the cylinder was ſo tranſparent, that, 'as the ſun ſhone, I ſaw the clouds behind it. 'The cloud which produced ſo many water-'ſpouts extended nearly from ſouth-eaſt to 'ſouth-weſt; and the large water-ſpout under 'conſideration appeared in the ſouth-ſouth-weſt 'from my ſtation. The ſun was very low; for 'the days were then about the ſhorteſt. I ſaw no 'rain proceed from the cloud: Its height ſeem-'ed to be from five to ſix hundred fathoms.'

The more the ſky is obſcured with clouds, water-ſpouts, and the phaenomena which accompany them, are the more eaſily obſerved.

M. de la Nux thinks, and perhaps with reaſon, that water-ſpouts are nothing but viſcous portions of a cloud driven off by different whirlwinds, *i. e.* by the whirlings of the ſuperior air ſinking into the maſs of vapours of which the whole cloud is compoſed.

What ſeems to prove that theſe water-ſpouts are compoſed of viſcous parts, is the tenaciouſneſs of their coheſion; for they make inflexions and curvatures in every direction, without breaking: If the matter of water-ſpouts was not viſcous, how can we conceive that they ſhould, without breaking, bend and obey the motion of the winds? If all the parts did not firmly adhere, the wind would diſſipate them, or, at leaſt, make them change their form. But, as the form, both of the large and ſmall water-ſpouts, is uniformly the ſame, this is almoſt a certain indication of the viſcous tenacity of the matter of which they are compoſed.

Thus the baſis of the matter of water-ſpouts is a viſcous ſubſtance contained in the clouds, and every water-ſpout is formed by a whirlwind of air preſſing through the maſs of vapours, and, by blowing up the inferior part of the cloud, pierces it, and deſcends with its covering of viſcous matter. And, as complete water-ſpouts deſcend from the cloud to the ſurface of the ſea, the water muſt boil and whirl at the place to which the end of the water-ſpout is directed;

becauſe the air blows from the extremity of the water-ſpout like the tube of a pair of bellows. The effects of this blowing upon the ſea will augment, in proportion as the cylinder approaches the ſurface of the water; and, when the orifice of the tube enlarges, a greater quantity of air is permitted to eſcape, and the agitation of the water is, of courſe, increaſed.

It has been imagined, that water-ſpouts carried off and contained great quantities of ſea-water: The rains, or rather the ſpray, which often fall in the neighbourhood of water-ſpouts, have ſtrengthened this prejudice. The canal in the middle of every ſpecies of water-ſpout is always tranſparent, on whatever ſide it is viewed. If the water of the ſea ſeems to riſe, it is not in this canal, but only on its ſides. Almoſt every water-ſpout ſuffers inflections, and often in oppoſite directions, in the form of an *S*, the one end of which is in the cloud, and the other in the ſea. Hence theſe water-ſpouts of which we have been treating, cannot contain water either to be poured into the ſea, or raiſed to the cloud. Of courſe, they can be attended with no danger, except what proceeds from the impetuoſity of the air which eſcapes from their inferior orifice; for we are aſſured by every perſon who has had an opportunity of obſerving theſe water-ſpouts, that they are ſolely compoſed of air confined in a viſcous cloud, and determined by its whirling to the ſurface of the ſea.

M. de la Nux has ſeen water ſpouts around the iſle of Bourbon in the months of January, May, June, and October, *i. e.* in all ſeaſons of the year. He has ſeen them in calm weather, and during the higheſt winds. Theſe phaenomena, however, may be ſaid to be rare, and ſeldom appear but upon the ſea; becauſe the viſcoſity of the clouds can only proceed from the bituminous and greaſy particles raiſed, by the heat of the ſun and the winds, from the waters of the ſea, and collected in the clouds near its ſurface. It is for this reaſon that water-ſpouts ſeldom apper on land, where there is not, as on the ſurface of the ſea, a ſufficient quantity of bituminous and oily particles to be exhaled by the action of the ſun. They are ſometimes, however, obſerved on land, and even at great diſtances from the ſea; this effect may be produced, when viſcous clouds have been rapidly driven by a violent wind from the ſea toward the land. M. Grignon, in the month of June 1768, ſaw a well formed water-ſpout in Lorrain near Vauvillier, among the hills which are a continuation of the Voſges. It was about fifty fathoms high. Its form was that of a column, and it communicated with a large thick cloud. It was impelled by one or ſeveral winds, which made the water-ſpout turn rapidly; and it produced lightning and thunder. This water-ſpout continued ſeven or eight minutes only, and broke upon the baſe of the hill, which is from five to ſix hundred feet high *.

Water-ſpouts have been mentioned by ſeveral voyagers; but no man has examined them with ſuch accuracy as M. de la Nux. For example, theſe voyagers tell us, that, when water-ſpouts are forming, a black ſmoke riſes on the ſurface of the ſea: This appearance, we are certain, is deceitful, and proceeds ſolely from the ſituation of the obſerver. If he is placed on a ſituation ſo elevated that the diſtance of the whirling excited in the water by the ſpout, exceeds not his ſenſible horizon, he will ſee nothing but the water riſing and falling back in rains, without any mixture of ſmoke. This fact is apparent when the ſun ſhines on the place where the phaenomenon happens.

Theſe water-ſpouts have nothing in common with thoſe agitations and ſmoke ſometimes produced by ſubmarine fires, and of which we have formerly treated. Water-ſpouts neither contain nor excite any ſmoke. They are every where rare: They are moſt frequent in the ſeas of warm climates, and where, at the ſame time, calms are common, and the winds are moſt inconſtant. They are likewiſe more frequent, perhaps, near iſlands and coaſts than in the open ſea.

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* Note communicated by M. Grignon to M. de Buffon, Aug. 6. 1777.

ADDITIONS to the article, Of Earthquakes and Volcano's, Vol. I. p. 382.

I.

Of Earthquakes.

EARTHQUAKES are produced by two cauſes: The firſt is the ſudden ſinking of cavities in the bowels of the earth; and the ſecond, which is ſtill more frequent and more violent than the firſt, is the action of ſubterraneous fires.

When a cavern ſinks in the middle of a continent, it produces a commotion which extends to a greater or ſmaller diſtance, in proportion to the quantity of motion excited by the fall of this maſs of earth; and, if this maſs is inconſiderable, or falls from no great height, it will not produce a ſucculſion ſo violent as to be perceived at a great diſtance; the effect is limited to the neighbourhood of the ſunk cavern; and if the movement is propagated to greater diſtances, it is only by ſlight tremblings or vibrations.

As moſt of the primitive mountains reſt upon caverns, becauſe, at the moment of their conſolidation, theſe eminences were blown up by the action of the internal fire, ſinkings in the mountains have happened, and ſtill happen, whenever the vaults of the caverns are undermined by water, or ſhaken by any convulſion. An entire portion of a mountain ſometimes ſinks perpendicularly, but oftener inclines, and not unfrequently reverſes. Of this we have ſtriking examples in ſeveral of the Pyrennees, where the ſtrata, formerly horizontal, are often inclined more than forty-five degrees; which ſhows, that the entire maſs of each portion of the mountain, whoſe ſtrata were parallel to each other, has inclined by the lump, and, in the moment of its ſinking, reſted upon a baſe inclined to the horizon forty-five degrees. This is the moſt general cauſe of the inclination of ſtrata in mountains. For the ſame reaſon, we often find, between the adjacent eminences, ſtrata which deſcend from the firſt and riſe to the ſecond, after having traverſed the valley. Theſe ſtrata are horizontal, and are bedded at the ſame height in the two oppoſite hills, between which the cavern had fallen in. The earth ſinks down, and the valley is formed, without producing any other derangement than a greater or ſmaller inclination of the ſtrata, according to the depth of the valley, or the declivity of the two oppoſite hills.

This is the only ſenſible effect of the ſinking of caverns in mountains and other parts of continents. But, whenever this effect happens in the bottom of the ſea, where ſinkings muſt be more frequent than on the land, becauſe the water perpetually undermines the vaults in every place where they ſupport the bottom of the ocean, theſe ſinkings not only derange and incline the ſtrata, but ſenſibly lower the level of the ſea. From the firſt occupation of the waters, their level has been depreſſed two thouſand fathoms by theſe ſinkings; and, as all the ſubmarine caverns have not yet fallen in, it is more than probable, that the baſin of the ſea, by growing more and more deep, will leſſen its ſurface, and, of courſe, that the extent of all the continents will always continue to augment by the retreat and ſinking of the waters.

A ſecond and more powerful cauſe than the firſt concurs in producing the ſame effect. This cauſe is the rupture and ſinking of caverns by the action of ſubmarine fires. It is certain, that no motion or ſinking in the bottom of the ſea can happen without diminiſhing its ſurface: And, if we conſider the general effects of ſubterraneous fires, we will perceive that, as long as there is fire, the commotions of the earth will not be confined to ſimple tremblings; for the efforts of fire raiſe and open the ſea and the land by violent and reiterated ſuccuſſions, which not only overturn and deſtroy the adjacent lands, but ſhake thoſe that are diſtant, and ravage or derange every thing in the route of their direction.

The earthquakes occaſioned by ſubterraneous fires generally precede eruptions of volcano's, and ſometimes ceaſe the moment the fire opens a paſſage through the earth, and carries its flames into the air. Theſe dreadful earthquakes ſometimes continue during the whole time of eruptions. Theſe two effects are intimately connected. There is never a great eruption of a volcano without being preceded, or at leaſt accompanied, with an earthquake. But we often feel very violent ſuccuſſions of the earth without any eruption of fire. Thoſe movements in which fire has no part, proceed not only from the firſt cauſe, the falling in of caverns, but likewiſe from the action of ſubterraneous winds and ſtorms. There are many examples of lands raiſed or ſunk by the force of theſe internal winds. Sir William Hamilton, a man as reſpectable for his private character, as admirable for the extent of his knowledge and reſearches on this ſubject, told me that he had ſeen between Trente and Verona, near the village of Roveredo, ſeveral little hills compoſed of large maſſes of calcarious ſtones, which had evidently been raiſed by different exploſions of ſubterraneous winds. There is no indication of the action of fire upon any of theſe rocks or their fragments. The whole country, on both ſides of the highway, for an extent of near a league, has, from place to place, been overturned by the prodigious efforts of ſubterraneous winds: The inhabitants ſay that it happened ſuddenly, and was the effect of an earthquake.

But the force of the wind, however violent, appears not to be a cauſe ſufficient to produce ſuch great effects; and, though there be no marks of fire in theſe little hills raiſed by the commotion of the earth, I am perſuaded that they have been elevated by electrical exploſions of ſubterraneous thunder, and that the internal winds have contributed to this effect ſolely by producing electrical ſtorms in the cavities of the earth. Hence all convulſive movements of the earth may be referred to three cauſes: The firſt and moſt ſimple is the ſinking of caverns; the ſecond, ſtorms and ſubterraneous thunder; and the third, the action of fire kindled in the interior parts of the globe. It is eaſy to aſcribe to one or other of theſe three cauſes all the phaenomena which accompany or ſucceed earthquakes.

Commotions of the earth ſometimes give riſe to eminences; but they more frequently produce gulfs. On the 15th day of October 1773, a gulf opened in the territory of Induno, in the

State of Modena, the cavity of which was more than four hundred fathoms wide by two hundred deep *. In 1726, a mountain of a conſiderable height, ſituated in the northern part of Iceland, was ſunk in one night by an earthquake, and a very deep lake aſſumed its place. The ſame night, about a league and a half diſtant, an ancient lake, the depth of which was unknown, was entirely dried up, and its bottom raiſed in ſuch a manner as to form a pretty high hill, which ſtill exiſts †. In the ſeas in the neighbourhood of New Britain, M. Bougainville remarks, earthquakes have terrible effects on navigation. On the 17th of June, the 12th and 27th of July 1768, there were three earthquakes at Boero, and on the 22d of the ſame month, one at new Brittany. Theſe earthquakes ſometimes annihilate iſlands and known ſandbanks, and ſometimes create them ‡.

There are earthquakes which extend to great diſtances; but they are always longer than broad. One of the moſt conſiderable was that felt in Canada in the year 1663. It extended more than two hundred leagues in length and one hundred in breadth, *i. e.* more than twenty thouſand ſuperficial leagues. The effects of the laſt earthquake in Portugal, which happened in our own time, were felt ſtill farther. M. le Chevalier de Saint-Sauveur, King's commandant at Merucis, informed M. de Genſanne, that, when walking on the left margin of Jouante in Languedoc, the ſky ſuddenly became very dark, and that, in a moment after, he perceived, at the foot of the hill which is ſituated to the right of that river, a terrible bright globe of fire: Immediately there aroſe from the bowels of the earth a conſiderable maſs of rocks, and the whole chain of mountains ſplit from Merucis to Florac, an extent of near ſix leagues. This rent, in ſome places, is more than two feet wide, and has partly fallen in *. There are other earthquakes which produce little or no commotion. Kolbe relates, that, on the 24th of September 1707, from eight to ten o'clock before noon, the ſea roſe upon the land at the Cape of Good Hope and deſcended ſeven times ſucceſſively, and with ſuch rapidity, that, from one moment to another, the place was alternately covered and left by the waters †.

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* Journ. hiſt. et politique, Dec. 10. 1773, *art. Milan.*

† Melanges interaſſans, tom. 1. p. 159.

‡ Voyage autour du Monde, tom. 2. p. 278.

With regard to the effects of earthquakes, the falling of mountains, and the ſinking of caverns, I ſhall ſubjoin a few facts, which are both

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* Hiſt. Nat. de Languedoc, par M. de Genſanne, tom. 1. p. 231.

† Deſcript. du Cap de Bonne-Eſperance, tom. 2. p. 237.

both recent and well atteſted. In Norway, a whole promontory called *Hammersfieids*, ſuddenly fell [*]. A very high mountain, near that of Chimboraço, one of the higheſt of the Cordeliers in the province of Quito, tumbled down in a moment. This fact, with all its circumſtances, is related in the memoirs of M. de la Condamine and Bouguer. Similar fallings and ſinkings often happen in the ſouthern iſlands of India. At Gamma-canore, where the Dutch have a ſettlement, a high mountain fell ſuddenly in the year 1673, when the weather was fine: It was followed by an earthquake, which overturned the neighbouring villages, and deſtroyed ſeveral thouſands of perſons [†]. On the 11th of Auguſt 1772, in the iſland of Java and province of Cheribou, one of the richeſt ſettlements of the Dutch, a mountain, of about three leagues in circumference, ſuddenly ſunk, and roſe and ſunk alternately like waves in a ſtormy ocean: It at the ſame time threw out many globes of fire, which were ſeen at a great diſtance, and gave a light as brilliant as that of day: All the plantations, together with about two thouſand one hundred and forty inhabitants, without reckoning ſtrangers, were entirely ſwallowed up [‡]. We might recite many other examples of the ſinking of

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[*] Hiſt. Nat. de Norwége, par Pontoppidan: *Journal étranger, Août* 1755.

[†] Hiſt. gen. de Voyages, tom. 17. p. 54.

[‡] See gazette de France, 21. Maii 1773. *art. de la Haie.*

lands and ſwallowing of mountains by the rupture of caverns, and the ſucceſſions occaſioned by earthquakes and the action of volcanoe's: But we have ſaid enough to eſtabliſh the general concluſions we have drawn from the facts already related.

II.

Of Volcano's.

THE ancients have left us ſome notices concerning the volcano's which were known to them, and particularly thoſe of Ætna and Veſuvius. Several learned and curious obſervers have in our days examined more minutely the form and effects of theſe volcano's. On comparing their deſcriptions, the firſt obſervation that preſents itſelf, is the folly of tranſmitting to poſterity the exact topography of theſe burning mountains. Their form may be ſaid to change daily; their ſurface riſes or ſinks in various places; every eruption produces new gulfs or new eminences: To attempt to deſcribe all theſe changes, is to follow and paint the ſucceſſive ruins of a burning edifice. The Veſuvius of Pliny, and the Ætna of Empedocles, preſent very different aſpects from thoſe which have been ſo ably delineated by Sir William Hamilton and Mr Brydone; and, in a few ages, theſe recent deſcriptions will no longer reſemble their objects. Next to the ſurface of the ocean, nothing on this globe is ſo fluctuating and inconſtant as the ſurface of volcanic mountains: But even from this inconſtancy, and from the variation of form and movements, ſome general concluſions may be drawn, by bringing particular obſervations under one point of view.

III.

Of the Changes which have happened in Volcano's.

THE baſe of Ætna is about ſixty leagues in circumference, and its perpendicular height about two thouſand fathoms above the level of the Mediterranean ſea. We may, therefore, regard this enormous mountain as an obtuſe cone, the ſuperficies of which is not leſs than three hundred ſquare leagues. This conical ſurface is divided into four zones, ſituated concentrically above each other. The firſt is the largeſt, and, by a gradual aſcent, extends above ſix leagues from the moſt diſtant point at the foot of the mountain. This zone of ſix leagues broad is almoſt totally peopled and cultivated. The city of Catania and ſeveral villages are ſituated in this firſt zone, the ſurface of which exceeds two hundred and twenty ſquare leagues. The baſis of this vaſt territory conſiſts of various ſtrata of ancient and modern lavas, that have run from different parts of the mountain, from which exploſions of ſubterraneous fires have iſſued. The ſurface of this lava, mixed with aſhes thrown out from different craters, is converted into a fine ſoil, which is now ſown with grain and planted with vines, except in a few places where the lava is too recent, and ſtill remains uncovered with earth. About the top of the zone, we ſtill ſee ſeveral craters, more or leſs large and deep, from which the materials iſſued that have formed the upper ſtratum or ſoil.

The ſecond zone commences at the termination of theſe ſix leagues. This ſecond zone is an aſcent of about two leagues broad. Its declivity is every where more rapid than that of the firſt zone; and this rapidity augments in proportion as you approach toward the ſummit. The ſurface of this ſecond zone is about forty or forty-five ſquare leagues: Its whole extent is covered with magnificent foreſts, and form a fine belt of verdure to the white and hoary head of this venerable mountain. The ſoil of theſe fine foreſts is nothing but lava and aſhes converted by the operation of time into excellent earth. What is ſtill more remarkable, the ſurface of this zone is ſo unequal, that it every

very where preſents hills, or rather mountains, all of which have been produced by different eruptions from the ſummit of Ætna, and other craters below the ſummit, ſeveral of which have formerly acted in this very zone, now converted into foreſts.

Before arriving at the ſummit, and after having paſſed theſe fine foreſts, we traverſe a third zone, which gives birth to ſmall vegetables only. In winter, this region is covered with ſnow, which melts in ſummer. We afterwards meet with a line of permanent ſnow, which marks the commencement of the fourth zone, and extends to the top of the mountain. Theſe ſnows and ice occupy about two leagues from the region of ſmall vegetables to the ſummit, which is likewiſe covered with ſnow and ice. Its figure is an exact cone; and it contains the great crater of the volcano, from which are continually diſcharged immenſe volumes of ſmoke. The internal figure of the crater is that of an inverted cone. It is compoſed of nothing but aſhes and other burnt matters thrown out by the mouth of the crater, which is in the centre of the volcano. The external ſurface of the ſummit is very rough. The ſnow is covered with aſhes, and the cold is very piercing. On the north ſide of this region of ſnow, there are ſeveral ſmall lakes which never freeze. In general, the ſurface of this laſt zone is pretty equal, and obſerves the ſame declivity, except in a few places; and it is below this region only where we meet with a great number of inequalities, eminences, and hollows produced by eruptions, and where we ſee hills and mountains more or leſs recently formed, and compoſed of burnt matters rejected by theſe different mouths or craters.

In 1770, according to Mr Brydone, the crater on the top of Ætna was more than a league in circumference; and very different dimenſions have been aſcribed to it both by ancient and modern authors. All theſe authors, however, were right; for the dimenſions of this mouth of fire have undergone many alterations. All we can infer from the various deſcriptions that have been given of it, is, that the crater with its margins have been four times overturned within theſe ſix or ſeven hundred years. The materials of which it is compoſed fall back into the bowels of the mountain, are again rejected by freſh eruptions, and form a new crater, which augments and riſes by degrees, till it again falls back into the great gulf of the volcano.

The top of the mountain is not the only place from which the ſubterraneous fire has been diſcharged. Through the whole territory which forms the ſides and ridge of Ætna, and at great diſtances from the ſummit, there are many craters which give paſſage to the fire, and which are ſurrounded with broken rocks that had been diſcharged by different eruptions. We may even reckon ſeveral hills formed by the eruptions of theſe ſmall volcano's which ſurround the great one. Each of theſe hills has a crater at its top, in the centre of which is a deep mouth or gulf. Every eruption of Ætna has produced a new mountain; and, perhaps, Mr Brydone remarks, their number would determine, better than any other method, that of the eruptions of this famous volcano.

The city of Catania, which is ſituated at the foot of Mount Ætna, has often been laid in ruins by the lavas which iſſued from theſe new mountains during the time of their formation. In aſcending from Catania to Nicoloſi, we traverſe twelve miles through a country formed by ancient lavas, where we ſee the mouths of extinguiſhed volcano's, which at preſent are fertile lands, covered with graſs, corn, and vineyards. The lavas which form this region proceeded from the eruptions of the ſmall mountains, which are every where diſperſed over the ſides of Ætna: They are all without exception, either regular hemiſpheres or cones. In general, every eruption raiſed one of theſe mountains. Hence the action of the ſubterraneous fires does not always reach the ſummit of Ætna. They often iſſue from the ſides, and even [illegible] the foot of this burning mountain. Each eruption from the ſides of Ætna commonly produces a new mountain compoſed of rocks, ſtones, and aſhes projected to a great diſtance by the force of the fire ; and the magnitude of theſe new mountains is proportioned to the duration of the eruption. If it continues but a few days, it produces only a little hill, about a league in circumference at the baſe, and three or four hundred feet in perpendicular height. But, if the eruption continues ſome months, like that of 1669, it then gives riſe to a conſiderable mountain of two or three leagues in circumference, and nine hundred or a thouſand feet high ; and all theſe hills produced by Ætna, ſome of which are twelve thouſand feet high, appear only as ſmall elevations intended to accompany the majeſty of the parent mountain.

In Veſuvius, which is a very ſmall volcano when compared with Ætna, eruptions from the ſides of the mountain are rare, and the lava generally iſſues from the crater at the ſummit. But, in Ætna, eruptions more frequently proceed from the ſides than the top, and lava iſſues abundantly from every new mountain formed by theſe eruptions. Mr Brydone, according to the information he received from M. Recupero, ſays, that the maſſes of ſtones projected from Ætna riſe to ſuch a height that they take twenty-one ſeconds of time in deſcending to the earth; while thoſe of Veſuvius fall in nine ſeconds; hence the ſtones projected by Veſuvius riſe to the height of 1215 feet, and thoſe projected by Ætna riſe 6615 feet; from which we may conclude, if the obſervations be accurate, that the force of Ætna is to that of Veſuvius as 441 to 81, *i. e.* five or ſix times greater. That Veſuvius is a very feeble volcano, when compared to Ætna, is proved in a more forcible manner by this circumſtance, that Ætna has actually produced other volcano's, which are larger than that of Veſuvius.

'Not a great way from this cavern, are two 'of the moſt beautiful mountains of all that 'number that ſpring from Ætna. I mounted 'one of our beſt mules, and with a good deal 'of difficulty arrived at the ſummit of the high'eſt of them, juſt a little before ſun-ſet. The 'proſpect of Sicily, with the ſurrounding ſea 'and all its iſlands, was wonderfully noble. The 'whole courſe of the river Semetus, the ruins 'of Hybla, and ſeveral other ancient towns; 'the rich corn-fields and vineyards on the low'er region of the mountain, and the amazing 'number of beautiful mountains below, made a 'delightful ſcene. The hollow craters of theſe 'two mountains are each of them conſiderably 'larger than that of Veſuvius. They are now 'filled with ſtately oaks, and covered to a great 'depth with the richeſt ſoil. I obſerved that 'this region of Ætna, like the former, is com'poſed of lava; but this is now covered ſo deep 'with earth, that it is no where to be ſeen, but 'in the beds of the torrents. In many of theſe 'it is worn down by the water to the depth of 'fifty or ſixty feet, and in one of them ſtill con'ſiderably more. . . This conical mountain is of 'a very great ſize; its circumference cannot be 'leſs than ten miles. Here we took a ſecond 'reſt, as the greateſt part of our fatigue ſtill re'mained. The mercury had fallen to 20 : $4\frac{1}{2}$. '—We found this mountain exceſſively ſteep; 'and although it had appeared black, yet it was 'likewiſe covered with ſnow. . . . The preſent 'crater of this immenſe volcano is a circle of a'bout three miles and a half in circumference. 'It goes ſhelving down on each ſide, and forms 'a regular hollow like a vaſt amphitheatre. 'From many places of this ſpace, iſſue volumes 'of ſulphureous ſmoke, which, being much 'heavier than the circumambient air, inſtead of 'riſing in it, as ſmoke generally does, imme'diately on its getting out of the crater, rolls 'down the ſide of the mountain like a torrent, 'till coming to that part of the atmoſphere of 'the ſame ſpecific gravity with itſelf, it ſhoots off 'horizontally, and forms a large track in the 'air, according to the direction of the wind; 'which, happily for us, carried it exactly to the 'ſide oppoſite to that where we were placed.

'The crater is ſo hot, that it is very dangerous, 'if not impoſſible, to go down into it; beſides, 'the ſmoke is very incommodious, and, in 'many places, the ſurface is ſo ſoft, there have 'been inſtances of people ſinking down in it, 'and paying for their temerity with their lives. 'Near the centre of the crater is the great mouth 'of the volcano. . . . When we arrived at the 'foot of the cone, we obſerved ſome rocks of 'an incredible ſize, that have been diſcharged 'from the crater. The largeſt that has been 'obſerved from Veſuvius, is a round one of about twelve feet in diameter. Theſe are much 'greater; indeed almoſt in proportion of the 'mountains to each other.'

As all that region from the top of Ætna, to the diſtance of two leagues below, preſents an equal ſurface, without hills or valleys, and as the ruins of Empedocles the philoſopher's tower, who lived four hundred years before the Chriſtian aera, are ſtill to be ſeen, it is probable, that, during all this period, the great crater has made few or no eruptions. Hence the force of the fire has diminiſhed, as it no longer acts with violence at the ſummit, and as all the modern eruptions have happened in the lower regions of the mountain. However, within theſe few centuries, the dimenſions of the great crater have been often changed, as appears from the meaſurements of Sicilian authors at different periods.

Sometimes it falls down, and is again gradually elevated till it falls afreſh. The firſt of theſe fallings, which are well atteſted, happened in the year 1157, a ſecond in 1329, a third in 1444, and the laſt in 1669. But, from theſe facts we ſhould not conclude, as Mr Brydone has done, that the crater will ſoon ſuffer another overthrow. The notion, that this effect ſhould be produced every hundred years, ſeems to have no foundation. I ſhould rather imagine, that, as the fire no longer acts with violence at the ſummit, its force has diminiſhed, and will continue to diminiſh, in proportion as the ſea retires: It has already retired ſeveral miles by the action of the volcano, which has formed large banks and bulwarks by vaſt torrents of lava. Beſides, we know, from the diminiſhed rapidity of Scylla and Charybdis, and ſeveral other indications, that the Sicilian ſea has ſunk conſiderably within theſe two thouſand five hundred years. We may, therefore, conclude that this ſea will continue to ſink, and, of courſe, that the action of the neighbouring volcano's will not relax; ſo that the crater of Ætna may remain during a long time in its preſent ſtate; and, if ever it falls back into the gulf, it will probably be for the laſt time. I farther preſume, that Ætna ought to be regarded as one of the primitive mountains, on account of its height and the immenſity of its ſize, and that it began to act at the remote period when the waters firſt retreated. Its action, however, ceaſed after this retreat, and was not renewed till that modern period when the Mediterranean ſea, being elevated by the rupture of the Boſphorus and the Straits of Gibraltar, deluged the land between Sicily and Italy, and approached to the baſis of Ætna. Perhaps the firſt of theſe eruptions is ſtill poſterior to this epoch of Nature. 'It is evident,' Mr Brydone remarks, 'that Ætna did not burn in 'the days of Homer, nor for a long time before, 'otherwiſe it would have been impoſſible that 'this poet ſhould have talked ſo much of Sicily, 'without mentioning an object ſo aſtoniſhing.' This remark of Mr Brydone is extremely juſt; and, of courſe, the firſt known eruptions of Ætna ſhould be dated after the age of Homer. But we perceive, from the poetical alluſions of Pindar and Virgil, and from the deſcriptions of ancient and modern authors, that, in the ſpace of eighteen or nineteen centuries, the whole face of this mountain and of the adjacent country has been changed by earthquakes, eruptions, torrents of lava, and the formation of hills and gulfs by theſe commotions. For the facts above related I am indebted to Mr Brydone's excellent performance; and I have too high an eſteem for Mr Brydone to believe that he can be offended, becauſe I do not agree with him as to the force of volcano's, and ſome other concluſions he has drawn from theſe facts. No preceding author has obſerved with equal acuteneſs, or preſented ſuch lively pictures of the objects he ſurveyed; the whole republic of letters, therefore, ought to unite in celebrating a work ſo deſerving of praiſe.

Torrents of glaſs in fuſion, which have received the denomination of lavas, are not the firſt effects of eruptions. Theſe eruptions are commonly announced by an earthquake more or leſs violent, which is the firſt effort of the ſubterraneous fire to eſcape from the bowels of the earth: It ſoon, however, opens a paſſage, which it enlarges by projecting rocks and every other obſtruction to its motion. Theſe materials, which are exploded to a great height, fall back upon each other, and form an eminence more or leſs conſiderable in proportion to the duration and violence of the eruption. As all the rejected matters are penetrated by fire, and moſt of them converted into burning aſhes, the eminence to which they give riſe is a mountain of ſolid fire, in which a great part of the matter is melted by the fervency of the heat. This melted matter ſoon begins to run, and generally flows to the foot of the new mountain by which it was produced. But, in ſmall volcano's, which have not force ſufficient to throw the ejected matters to a great diſtance, the lava iſſues from the top of the mountain. This effect is conſpicuous in the eruptions

ruptions of Veſuvius. The lava riſes in the centre of the crater. The volcano firſt throws out ſtones and aſhes, which fall perpendicularly back into the old crater and augments its ſize. It is through this additional matter, which has fallen back, that the lava opens a paſſage. Theſe two effects, though different in appearance, are nevertheleſs the ſame; for, in a ſmall volcano, which, like Veſuvius, has not force enough to give birth to new mountains by projecting its materials to a diſtance, the whole fall back upon the ſummit and increaſe its height; and it is at the foot of this new crown of matter that the lava forces its way and flows down the mountain. This laſt effort is generally ſucceeded by a repoſe of the volcano. The ſuccuſſions of the earth within, and the projections without, ceaſe as ſoon as the lava flows. But the torrents of this glaſs in fuſion produce effects ſtill more extenſive and diſaſtrous than the convulſions of the mountain during an eruption. Theſe rivers of fire ravage, deſtroy, and disfigure the ſurface of the earth. Nothing can oppoſe their dreadful progreſs. Of this the unfortunate inhabitants of Catania have had fatal experience. As their city had often been deſtroyed, either wholly or in part, by theſe torrents of lava, they built very ſtrong walls of fifty-five feet in height. Surrounded by theſe ramparts, they believe themſelves to be ſafe. The walls, it is true, reſiſted the heat and the weight of the torrent. But this reſiſtance ſerved only to dam up the lava, which roſe above the ramparts, fell back upon the city, and ravaged ever thing in its progreſs.

Theſe torrents of lava are often half a league, and ſometimes even two leagues broad.

‘ The laſt lava we croſſed before our arrival at ‘ Catania, is of a vaſt extent. I thought we never ‘ ſhould have done with it; it certainly is not ‘ leſs than ſix or ſeven miles broad, and appears ‘ in many places to be of an enormous depth.

‘ When we came near the ſea, I was deſirous ‘ to ſee what form it had aſſumed in meeting ‘ with the water. I went to examine it, and ‘ found it had driven back the waves for upwards ‘ of a mile, and had formed a large black high ‘ promontory, where before it was deep water. ‘ This lava, I imagined, from its barrenneſs, for ‘ it is as yet covered with a very ſcanty ſoil, had ‘ run from the mountain only a few ages ago; ‘ but was ſurpriſed to be informed by Signior ‘ Recupero, the hiſtoriographer of Ætna, that ‘ this very lava is mentioned by Diodorus Sicu- ‘ lus to have burſt from Ætna in the time of ‘ the ſecond Punic war, when Syracuſe was be- ‘ ſieged by the Romans. A detachment was ‘ ſent from Taurominum to the relief of the be- ‘ ſieged. They were ſtopped on their march ‘ by this ſtream of lava, which having reached ‘ the ſea before their arrival at the foot of the 'mountain, had cut off their paſſage; and obliged them to return by the back of Ætna, upwards of 100 miles about. His authority for this, he tells me, was taken from inſcriptions on Roman monuments found on this lava; and that it was likewiſe well aſcertained by many of the old Sicilian authors. Now, as this is about 2000 years ago, one would have imagined, if lavas have a regular progreſs in becoming fertile fields, that this muſt long ago have become at leaſt arable; this however is not the caſe, and it is as yet only covered with a very ſcanty vegetation, and incapable of producing either corn or vines. There are indeed pretty large trees growing in the crevices, which are full of a rich earth; but in all probability it will be ſome hundred years yet, before there is enough of it to render this land of any uſe to the proprietors.

'We paſſed the river Alcantara on our way to Piedmonte, over a large bridge built entirely of lava; and near to this the bed of the river is continued for a great way, through one of the moſt remarkable, and probably one of the moſt ancient lavas that ever run from Ætna. In many places the current of the river, which is extremely rapid, has worn down the ſolid lava to the depth of 50 or 60 feet. Recupero, the gentleman I have mentioned, who is engaged in writing the natural hiſtory of

Ætna, tells me, he had examined this lava with great attention, and he thinks that its courſe, including all its windings, is not leſs than 40 miles. It iſſued from a mountain on the north ſide of Ætna, and finding ſome valleys that lay to the eaſt, it took its courſe that way, interrupting the Alcantara in many places, and at laſt arrived at the ſea not far from the mouth of that river.

' The city of Jaci or Aci, and indeed all the towns on this coaſt, are founded on immenſe rocks of lava, heaped one above another, in ſome places to an amazing height; for it appears that theſe flaming torrents, as ſoon as they arrived at the ſea, were hardened into rock, which not yielding any longer to the preſſure of the liquid fire behind, the melted matter continuing to accumulate, formed a dam of fire, which, in a ſhort time, run over the ſolid front, pouring a ſecond torrent into the ocean: This was immediately conſolidated, and ſucceeded by a third, and ſo on. . . . The road from Jaci to this city is entirely over lava, and conſequently very fatiguing and troubleſome. Within a few miles of that place, we counted eight mountains formed by eruptions, with every one its crater, from whence the burnt matter was diſcharged. Some of theſe are very high, and of a great compaſs. It appears evidently, that the eruptions of

'Mount Ætna have formed the whole of this 'coaſt, and in many places have driven back 'the ſea for ſeveral miles from its ancient boundary. . . At Catania, near to a vault, which is 'now thirty feet below ground, and has probably been a burial place, there is a draw-well, 'where there are ſeveral ſtrata of lavas, with 'earth to a conſiderable thickneſs over the ſurface of each ſtratum. Recupero has made uſe 'of this as an argument to prove the great antiquity of the eruptions of his mountain. For 'if it requires two thouſand years or upwards 'to form but a ſcanty ſoil on the ſurface of a 'lava, there muſt have been more than that 'ſpace of time betwixt each of the eruptions 'which have formed theſe ſtrata. But what 'ſhall we ſay of a pit they ſunk near to Jaci, of 'a great depth? They pierced through ſeven 'diſtinct lavas one under the other, the ſurfaces 'of which were parallel, and moſt of them covered with a thick bed of rich earth. Now, 'ſays he, the eruption which formed the loweſt 'of theſe lavas, if we may be allowed to reaſon 'from analogy, muſt have flowed from the 'mountain at leaſt 14,000 years ago. . . .

'The great eruption of 1669, after ſhaking 'the whole country around for four months, 'and forming a very large mountain of ſtones 'and aſhes, burſt out about a mile above Monpelieri, and deſcending like a torrent, bore directly

'againſt

‘ againſt the middle of that mountain, and (they
‘ pretend) perforated it from ſide to ſide: This
‘ however I doubt, as it muſt have broken the
‘ regular form of the mountain, which is not
‘ the caſe. But certain it is, that it pierced it
‘ to a greath depth. The lava then divided into two branches; and ſurrounding this mountain, joined again on its ſouth ſide; and laying waſte the whole country betwixt that and
‘ Catania, ſcaled the walls of that city, and
‘ poured its flaming torrent into the ocean. In
‘ its way, it is ſaid to have deſtroyed the poſſeſſions of near 30,000 people, and reduced them
‘ to beggary. It formed ſeveral hills where
‘ there were formerly valleys, and filled up a
‘ large lake, of which there is not now the leaſt
‘ veſtige to be ſeen. . . . There is no part of the
‘ coaſt from Catania to Syracuſe nearer than
‘ thirty miles to its ſummit; and yet there has
‘ hardly been any great eruption, where the
‘ lava has not reached the ſea, and driven back
‘ its waters to a great diſtance, leaving high
‘ rocks and promontories, that for ever ſet its
‘ waves at defiance, and preſcribe their utmoſt
‘ limits. What a tremendous ſcene muſt the
‘ meeting betwixt theſe adverſe elements have
‘ formed?

‘ We may eaſily conceive the variety of
‘ changes this coaſt has undergone in the ſpace
‘ of ſome thouſands of years, as every great eruption

'ruption muſt have made a conſiderable diffe-'rence.—Virgil is wonderfully minute and ex-'act in his geography of Sicily; and this is the 'only part of the iſland that ſeems to be mate-'rially altered ſince his time. He ſays there was 'a very large port at the foot of Ætna, where 'ſhips were ſecure from every wind;

> "Portus ab acceſſu ventorum immotus et ingens;"

'of which, at preſent, there are not the leaſt 'remains. It is probably the ſame that was call-'ed by the Sicilians the port of Ulyſſes; which 'is often mentioned by their writers.—The 'place of its exiſtence is ſtill ſhewn betwixt 'three and four miles up the country, amongſt 'the lavas of Ætna. . . .

'The circumference of the great baſe of Æt-'na, Recupero told me, he had been at a good 'deal of pains to aſcertain; as it had generally 'been computed only at a hundred miles, or 'little more, although the radii of that circle 'had ever been eſteemed at thirty of thoſe miles; 'an abſurdity in computation that had put him 'upon making this inquiry. The reſult was, 'that taking the ſuppoſed diſtances of one place 'from another, all the way round, the ſum of 'the whole amounted to one hundred and eighty-'three miles: An immenſe circle ſurely, and 'which is ſtill enlarged by every conſiderable 'eruption.'

Here

Here we have a territory of about 300 ſuperficial leagues, all covered or formed by the projections of volcano's. In this territory, independent of the peak of Ætna, there are many other mountains, all of which are furniſhed with craters, and exhibit an equal number of particular volcano's. Ætna, therefore, muſt not be regarded as a ſingle volcano, but as an aſſemblage of volcano's, the greater part of which are extinguiſhed, or burn with a gentle fire, and a few of them ſtill act with violence. At preſent, the ſummit of Ætna throws out nothing but ſmoke; and there ſeems to have been no eruption from it for a very long period of time; becauſe it is ſurrounded, to the diſtance of two leagues, with an equal ſurface, and below this high region covered with ſnow, we find a large zone of vaſt foreſts, the ſoil of which is a fertile earth of ſeveral feet in thickneſs. This inferior zone is interſperſed with inequalities, and preſents heights, valleys, hills, and even pretty large mountains. But, as almoſt the whole of theſe inequalities are covered with a great thickneſs of earth, and as a long ſucceſſion of time was neceſſary to convert volcanic matters into vegetable ſoil, we ſhould regard the ſummit of Ætna, and the other mouths which ſurround it to the diſtance of four or five leagues, as volcano's almoſt extinct, or, at leaſt, ſtifled for a number of ages; for all the eruptions, the dates of which can be aſcertained for two thouſand five hundred years, have happened in the lower region, *i. e.* five, ſix, or ſeven leagues diſtant from the ſummit. The volcano's of Sicily ſeem to have had two different ages: The firſt very ancient, when the ſummit of Ætna began to act, and when the univerſal ocean left this ſummit dry, and ſunk ſome hundreds of fathoms below: It was at this period that the firſt eruptions happened, which produced lava at the ſummit, and gave riſe to thoſe hills found below in the region of foreſts; but afterwards, the waters continuing to ſink, they totally abandoned this mountain, as well as all the territories of Sicily and the adjacent continents. After this total retreat of the waters, the Mediterranean was only a lake of a moderate extent, and its waters were very diſtant from Sicily, and all the countries whoſe coaſts it now waſhes. During all this time, which laſted ſeveral thouſand years, Sicily was perfectly tranquil: Ætna, and the other ancient volcano's which ſurround its ſummit, had ceaſed to act; and it was not till after the augmentation of the Mediterranean by the waters of the ocean and of the Black ſea, *i. e.* after the rupture of the ſtraits of Gibraltar and of the Boſphorus, that the waters attacked the baſes of the new mountains of Ætna, and produced thoſe modern eruptions which have happened ſince the age of Pindar to the preſent time; for this poet is the firſt author who has taken notice of eruptions of volcano's in Sicily. Veſuvius was preciſely in the ſame ſituation: It was long one of the extinguiſhed volcano's of Italy, which are very numerous; and their eruptions were not renewed till after the waters of the Mediterranean were increaſed and reached the baſes of theſe inflammable mountains. The memory of the firſt eruptions, and even of all thoſe which preceded the age of Pliny, was entirely obliterated. Neither ſhould this circumſtance excite ſurpriſe; for ten thouſand years have, perhaps, elapſed ſince the general retreat of the waters to the augmentation of the Mediterranean, and an equal portion of time from the firſt eruption of Veſuvius till their removal. All theſe conſiderations ſeem to prove, that ſubterraneous fires cannot act with violence, unleſs when they are ſo near the ſea as to receive a ſhock from a great body of water. This reaſoning is confirmed by other phaenomena: Volcano's ſometimes throw out great quantities of water, and likewiſe torrents of bitumen. P. de la Torré, an able philoſopher, relates, that, on the 10th of March 1755, an immenſe torrent of water iſſued from the foot of the mountain, which deluged the neighbouring country. This torrent brought down ſuch a quantity of ſand, that it covered an extenſive plain. Theſe waters were very hot. The ſtones and ſand left on the plain differed not from thoſe found in the ſea. The torrent of water was immediately followed by another of inflamed matter, which proceeded from the ſame opening *.

The ſame eruption, 1755, was preceded, ſays M. D'Arthenay, by an inflammation ſo great, that it illuminated more than twenty-four miles of country along the coaſts of Catania. The exploſions were ſoon ſo frequent, that, on the 3d of March, we perceived a new mountain in the top of the old ſummit, in the ſame manner as lately happened to Veſuvius. Laſtly, the magiſtrates of Maſcali informed us, that, on the 9th of the ſame month, the exploſions were terrible; that the whole ſky was darkened with ſmoke; that, on the approach of night, it began to rain a deluge of ſmall ſtones, ſome of which weighed three ounces, and covered all the adjacent cantons; that this tremendous rain continued an hour and a quarter, and was ſucceeded by another of black aſhes, which laſted the whole night; that next day, about eight o'clock in the morning, the ſummit of Ætna threw out a river of water, which, for magnitude, might be compared to the Nile; that the moſt ancient and rugged mountains of lava were in an inſtant converted by this torrent into a vaſt plain of ſand; that the water, which for-

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* Hiſt. du Mont Veſuve, par le P. J. M. de la Torré; *Journal étranger, mois Janvier* 1576, *p.* 203.

fortunately ran not above half a quarter of an hour, was very hot; that the ſtones and ſand carried along with it differed not from thoſe of the ſea; that, after this inundation, there iſſued from the ſame mouth a ſmall rivulet of fire, which flowed during twenty-four hours; that, on the 11th, about a mile below this mouth, a rent happened through which iſſued a ſtream of lava, of about a hundred fathoms broad by two miles in length, and that it continued its courſe through the country the ſame day in which M. D'Arthenay wrote this relation *.

Let us attend to what Mr Brydon has remarked concerning this eruption. ‘ Part of the ‘ fine foreſts which compoſe the ſecond region ‘ of Ætna was deſtroyed by a very ſingular e- ‘ vent, not later than the year 1755. During ‘ an eruption of the volcano, an immenſe tor- ‘ rent of boiling water iſſued, as is imagined, ‘ from the great crater of the mountain, and in ‘ an inſtant poured down to its baſe; over- ‘ whelming and ruining every thing it met with ‘ in its courſe. Our conductors ſhewed us the ‘ traces of this torrent, which are ſtill very viſible; ‘ but are now beginning to recover verdure and ‘ vegetation, which for ſome time appeared to ‘ have been loſt. The track it has left ſeems ‘ to

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* Mem. des Savans étrangers, imprimés comme ſuite des mem. de l'acad. des ſciences, tom. 4. p. 147.

'to be about a mile and a half broad; and in 'ſome places ſtill more.

'The common opinion, I find, is, that this 'water was raiſed by the power of ſuction, 'through ſome communication betwixt the vol'cano and the ſea; the abſurdity of which is 'too glaring to need a refutation. The power 'of ſuction alone, even ſuppoſing a perfect va'cuum, could never raiſe water to more than 'thirty-three or thirty-four feet, which is e'qual to the weight of a column of air the whole 'height of the atmoſphere.'

I muſt here obſerve, that Mr Brydone ſeems to have deceived himſelf; for he confounds the force ariſing from the weight of the atmoſphere with the force of ſuction produced by the action of fire. The force of the air, when a vacuum is made, is indeed limited to thirty-four feet. But the force of ſuction by fire has no limits: It is always proportioned to the quantity and intenſity of the heat by which it is produced, as is evident from the common effects of blaſt furnaces. Hence the opinion of the *enlightened people of the country*, inſtead of being abſurd, ſeems to be well founded. It is neceſſary that the cavities of volcano's ſhould communicate with the ſea: Without this communication, ſuch immenſe torrents of water could not be thrown out, nor indeed could any eruption ever happen; for no power, except the ſhock produced by the mingling of fire and water, could give riſe to ſuch violent effects.

The volcano of Pacayita, called the *water volcano* by the Spaniards, in all its eruptions, throws out torrents of water. The laſt eruption, in the year 1773, deſtroyed the city of Guatimala, and the torrents of water and lava deſcended to the South Sea.

With regard to Veſuvius, it has been remarked, that a wind, which blows from the ſea, penetrates into the mountain. The noiſe it makes in certain cavities is heard, as if ſome torrent paſſed below: This noiſe ceaſes whenever the land winds blow, and, at the ſame time, the exhalations from the mouth of Veſuvius become leſs conſiderable. But, when the wind blows from the ſea, this noiſe which reſembles that of a torrent, recommences, and the exhalations of flame and ſmoke increaſe. The water of the ſea, by thus inſinuating itſelf into the mountain, ſometimes in greater, and ſometimes in ſmaller quantities, is the reaſon why this volcano has often thrown out both aſhes and water *.

The learned M. D'Arthenay, who has compared the modern with the ancient ſtate of Veſuvius, relates, that, during the interval which preceded the eruption 1631, the funnel or crater

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* Deſcript. hiſtorique et philoſ. de Veſuve, par M. l'Abbé Mecatti; *journal étranger, mois Oct.* 1754.

ter of the mountain was covered with trees and verdure; that the ſmall plain which bounds it produced excellent paſture; that, in departing from the ſuperior margin of the crater, we have a mile to deſcend before we arrive at this plain, in the middle of which was another gulf. We deſcended this gulf about a mile, by narrow and winding roads of an equal declivity, which led into a vaſt ſpace ſurrounded with caverns, from whence there iſſued *winds ſo impetuous and ſo cold, that it was impoſſible to endure them.* According to the ſame obſerver, the ſummit of Veſuvius was then five miles in circumference. We ſhould not, therefore, be ſurpriſed, that ſome philoſophers have maintained that what ſeems now to be two mountains, was formerly one; that the volcano was in the center, but that the ſouth ſide, having fallen by the force of ſome eruption, produced the valley which ſeparates Veſuvius from Mount *Somma* *.

M. Steller remarks, that the volcano's in the north of Aſia are almoſt always *iſolated*; that they have nearly the ſame ſurface; and that there are always lakes on the ſummits, and hot waters at the foot of thoſe mountains whoſe volcano's are extinct. This, he adds, is a farther proof of the correſpondence eſtabliſhed by Nature between the ſea, mountains, volcano's, and hot waters. We find many ſprings of hot water in different parts of Kamtſchatka *. In the iſland of Sjanw, forty leagues diſtant from Ternate, there is a volcano, which often throws out water, aſhes †, &c. But it is unneceſſary to accumulate more facts to prove the communication of volcano's with the ſea. The violence of their eruptions would be ſufficient to juſtify the preſumption; and the general fact, that all acting volcano's are ſituated near the ſea, completes the demonſtration. However, as ſome philoſophers have denied the reality and even the poſſibility of this communication of volcano's with the ſea, I ſhall mention another fact related by M. de la Condamine, a man equally enlightened as worthy of credit. 'On the 14th 'of June 1755,' he remarks, 'I mounted to 'the ſummit of Veſuvius, and even to the brink 'of the funnel formed round the mouth of the 'volcano by its laſt exploſion; and I perceived 'in the gulf, about forty fathoms deep, a 'great cavity reſembling a vault toward the 'north of the mountain. I threw down large 'ſtones into this cavity, and counted twelve 'ſeconds before the noiſe of their rolling ceaſed. At the end of their fall I heard a noiſe 'ſimilar to that of a ſtone falling into a mire; 'and, when nothing was thrown in, I heard a 'noiſe

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* Obſerv. ſur le Veſuve, par M. d'Arthenay; *Journal de Savans étrangers, tom. 4. p.* 147.

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* Hiſt. gen. des voyages, tom. 19. p. 238.

† Ibid. tom. 17. p. 54.

‘ noiſe like that of agitated waves†.’ If the fall of the ſtones had been perpendicular, and met with no obſtacle, twelve ſeconds would have given a depth of 2160 feet, and the bottom of the gulf would, on this ſuppoſition, be deeper than the level of the ſea; for, according to le P. de la Torré, in 1753 this mountain was only 1677 feet above the ſurface of the ſea, and this elevation has been diminiſhed ſince that period. Hence we may conclude, that the caverns of this volcano deſcend below the level of the ſea, and, of courſe, they may have ſubterraneous communications.

On the 15th of July 1753, I received, from an eye-witneſs, and an accurate obſerver, a diſtinct detail of the then condition of Veſuvius. I ſhall ſubjoin it in the words of the author, becauſe it will tend to fix our ideas concerning what is to be farther apprehended from the effects of this volcano, the force of which ſeems to be greatly diminiſhed.

‘ Having arrived at the foot of the mountain, ‘ which is about two leagues diſtant from Na-‘ ples, we mounted during an hour and a half ‘ upon aſſes, and an equal portion of time was ‘ employed in completing the journey on foot. ‘ This is the ſteepeſt and moſt fatiguing part of ‘ the way. We held by the belts of two men

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† Voyage en Italie, par. M. de la Condamine; *Mem. de l'Acad. des Sciences, année* 1757, *p.* 371.

‘ who went before, and we climbed among aſh‘ es and ſtones formerly exploded.

‘ In our aſcent, we ſaw the lavas of different ‘ eruptions. The moſt ancient, whoſe age is ‘ uncertain, but tradition aſſigns it two hundred ‘ years, is of an iron-gray colour, and has all ‘ the appearance of a ſtone: It is uſed for pa‘ ving the ſtreets of Naples, and in other works ‘ of maſonry. We found others, which were ‘ ſaid to be ſixty, forty, and twenty years old. ‘ The laſt was thrown out in the year 1752. . . ‘ Theſe different lavas, except the moſt ancient, ‘ when viewed at a diſtance, have the appear‘ ance of a blackiſh brown rugged earth, more ‘ or leſs recently laboured. When viewed near‘ er, it is a matter perfectly ſimilar to the refuſe ‘ of iron founderies. It is more or leſs compo‘ ſed of earth and ferruginous matter, and ap‘ proaches more or leſs to the nature of ſtone.

‘ When arrived at the top, which before the ‘ eruption was ſolid, we find the firſt baſin, ‘ whoſe circumference is ſaid to be two Italian ‘ miles, and its depth appears to be about forty ‘ feet. It is ſurrounded with a cruſt of earth, ‘ which gradually thickens toward the baſe, and ‘ its upper margin is two feet broad. The bot‘ tom of this baſin is covered with a greeniſh ‘ yellow ſulphureous matter, which is hard and ‘ warm, but does not burn; and ſmoke iſſues ‘ through different fiſſures.

‘ In the centre of this baſin, we ſee a ſecond, ‘ which is about half the circumference and half ‘ the depth of the former. Its bottom is co- ‘ vered with a blackiſh brown matter, ſimilar to ‘ the freſheſt lavas we find on the road.

‘ In the ſecond baſin, there is a ſmall mount ‘ which is hollow internally, open at the top, ‘ and likewiſe open from the top to the baſe to- ‘ ward that ſide of the mountain where we a- ‘ ſcended. This lateral opening is about twenty ‘ feet broad at the top, and four feet at the baſe. ‘ The height of this ſmall mount is about forty ‘ feet; the diameter of the baſe is about as ‘ much, and that of the opening at the top a- ‘ bout twenty feet.

‘ This baſe riſes about twenty feet above the ‘ ſecond baſin, and forms a third baſin, which ‘ is filled with a liquid and burning matter, and ‘ has a perfect reſemblance to the melted metal ‘ in an iron furnace. This matter perpetually ‘ boils with great violence. Its movements have ‘ the appearance of a lake moderately agitated, ‘ and the noiſe it produces is ſimilar to that of ‘ waves.

‘ Every minute, quantities of this matter are ‘ projected into the air, like water thrown up ‘ by many jets-d'eaux. Theſe projections pro- ‘ duce the appearance of burning ſheafs of ‘ wheat, which riſe to the height of thirty or ‘ forty feet, and fall back in various curves,

‘ partly into their own baſin, and partly ‘ the ſecond, which is covered with a black ‘ matter. It is the reflected light of theſe ‘ burning jets which is ſeen from Naples du‘ring the night. The noiſe they make in ‘ their elevation and fall ſeems to be compoſed ‘ of that of fire-works, and the noiſe produced ‘ by the waves of the ſea, when violently daſh‘ed againſt a rock.

‘ The boilings and jets produce a perpetual ‘ evacuation of this matter. Through the aper‘ture of four feet, at the baſe of the ſmall ‘ mount, a burning rivulet of the ſame dimen‘ſions with the aperture continually flows, and ‘ deſcends in an inclined canal, and with a mean ‘ movement, into the ſecond baſin, where, after ‘ dividing into ſeveral rills, it ſtops and is ex‘tinguiſhed.

‘ This burning rivulet conſiſts of freſh lava, ‘ which runs only eight days. But, if it con‘tinues to augment, it will in time produce a ‘ new overflowing into the plain, ſimilar to that ‘ which happened two years ago. The whole ‘ is accompanied with a thick ſmoke, which has ‘ not the odour of ſulphur, but preciſely that ‘ which proceeds from a furnace where tiles ‘ are roaſted.

‘ We may, without danger, go round the ‘ margin of the crater; becauſe the little hollow ‘ mount, from which the burning projections ‘ are made, is ſufficiently diſtant to prevent all 'apprehenſions. We may alſo, without danger, deſcend into the firſt baſin; we may even 'go upon the margin of the ſecond, if the reverberation of the burning matter does not 'prevent us.

'This was the real ſtate of Veſuvius on the '15th of July 1753. But it perpetually changes its form and aſpect. It now throws out 'no ſtones, and we perceive no flame *.'

Theſe obſervations ſeem to prove, that the ſeat of the burning in this volcano, and perhaps in all others, is at no great depth in the bowels of the mountain, and that it is not neceſſary to ſuppoſe their fires on a level with, or lower than the ſea, and to make their exploſions from thence during the time of eruptions. It is ſufficient that there are caverns and perpendicular fiſſures below, or rather at the ſide of the fire, which ſerve as ventilators to the furnace of the volcano.

M. de la Condamine, who has had more opportunities than any other philoſopher, of examining a number of volcano's in the Cordelieres, has likewiſe explored that of Veſuvius, and all the adjacent territories.

'In the month of June 1755,' he remarks, 'the ſummit of Veſuvius formed an open funnel in a maſs of aſhes, calcarious ſtones, and

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* Note ſent to M. de Buffon from Naples in September 1753.

'ſulphur, which burned at different diſtances,' 'and tinged the ſurface with its colour. The 'fire ſtreamed through different crevices, in 'which the heat was ſo great, that, in a ſhort 'time, it inflamed a ſtick thruſt ſome feet down 'theſe fiſſures.

'For ſeveral years paſt, the eruptions of this vol'cano have been frequent; and, every time flames 'and liquid matter were thrown out, the moun'tain underwent conſiderable changes both in 'its height and external figure. . . . In a ſmall 'plain, on the ſide of the mountain compoſed 'of aſhes and ſtones projected from the volca'no, there is a breaſt of ſteep ſemicircular rocks 'of two hundred feet high, which bound this 'plain on the north. We perceived, near the 'crevices recently opened in the flanks of the 'mountain, the places through which the tor'rents of lava, with which the whole of this 'valley is filled, had iſſued during the laſt e'ruption.

'This ſpectacle preſents the appearance of me'tallic waves cooled and congealed. We may 'form an imperfect idea of it by imagining a 'ſea of thick and tenacious matter, the waves of 'which had begun to calm. This ſea has its 'iſlands: They are detached maſſes, like hol'low ſpongy rocks, whimſically interſperſed 'with vaults and grotto's, under which the 'burning liquid had made a kind of reſervoirs 'reſembling furnaces. From theſe grotto's, 'with their vaults and pillars, hang numbers of 'ſcoriae in the form of irregular grapes of all 'ſhades and colours. . . .

'All the mountains and coaſts in the envi- 'rons of Naples, are nothing but maſſes of burnt 'matter thrown out by volcano's which now no 'longer exiſt, and whoſe eruptions, which have 'been anterior to all hiſtory, probably formed 'the ports of Naples and Puzzoli. The ſame 'matters are conſpicuous on the whole road 'from Naples to Rome, and even at the port 'of Rome itſelf.

'The whole interior part of Mount Fraſcati, 'the chain of hills which extends from this place 'to Grotta-ferrata, Caſtlegandolfo, and as far 'as lake Albano, a great part of Mounts Tivo- 'li, Caprarola, Viterbe, &c. are compoſed of 'calcined ſtones, of pure aſhes, of ſcoriae, of 'matter ſimilar to the droſs of iron and burnt 'earth, and of real lava; laſtly, the whole mat- 'ters reſemble thoſe of which the ſoil of Portici 'is compoſed, and which have iſſued from the 'ſides of Veſuvius in ſo many different forms. '. . . Hence we muſt neceſſarily conclude, that all this part of Italy has been overturned by vol- 'cano's. . . .

'Lake Albano, whoſe margins are interſperſed with calcined matters, is nothing but the mouth of an ancient volcano. . . . The chain of Ita-

'lian volcano's extends as far as Sicily, and 'ſtill exhibits a number of fires under different 'forms; in Tuſcany, we have the exhalations of 'Firenzuola, and the warm waters of Piſa; in 'the Eccleſiaſtic ſtate, thoſe of Viterbe, of 'Norcia, of Nocera, &c.; in the kingdom of 'Naples, thoſe of Iſchia, Solfatara, and Veſu'vius; in Sicily and the iſlands adjacent to Æt'na, the volcano's of Lipari, Stromboli, &c. 'The other volcano's of this chain have been 'extinct from time immemorial, and have left 'ſuch relicks as, though they do not always 'ſtrike us at firſt ſight, fail not to be recogniſa'ble on an attentive examination *.

'It is very probable, ſays M. l'Abbé Mecati, 'that, in paſt ages, the kingdom of Naples, be'ſides Veſuvius, was infeſted with ſeveral other 'volcano's.'

'Mount Veſuvius,' le P. de la Torré remarks, 'ſeems to be a portion detached from that chain 'of mountains which, under the name of *A'pennines*, divides all Italy through its whole 'length. . . . . This volcano is compoſed of 'three different mountains, one of them is Ve'ſuvius properly ſo called; the other two are 'Mounts Somma and Otajano. The two laſt 'are ſituated toward the weſt, and form a kind

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* Voyage en Italie, par M. de la Condamine; Acad. des Sciences, année 1757, p. 371.—379.

‘ of ſemicircle round Veſuvius, with which they ‘ have a common baſe.

‘ This mountain was formerly ſurrounded ‘ with fertile fields, and itſelf covered with trees ‘ and verdure, except the ſummit, which was ‘ flat and ſterile, and where ſeveral open ca- ‘ verns were to be ſeen. The top was ſurround- ‘ ed with rocks, which rendered it of difficult ‘ acceſs. Theſe rocks were ſo high, that they ‘ concealed the valley between Veſuvius and ‘ Mounts Somma and Otajano. The ſummit ‘ of Veſuvius, which has ſince ſunk conſidera- ‘ bly, being then much more remarkable, it is ‘ not ſurpriſing that the ancients believed it had ‘ only one top. . . . .

‘ The breadth of the valley is 2220 Paris ‘ feet, and its length nearly the ſame. . . . ‘ It inveſts one half of Veſuvius, and, like all ‘ the ſides of the mountain, it is covered with ‘ burnt ſand and ſmall pumice ſtones. The ‘ rocks on Mounts Somma and Otajano ex- ‘ hibit a few herbs, and the ſurface of theſe ‘ mountains is covered with trees and verdure. ‘ Theſe rocks, at firſt ſight, have the appearance ‘ of burnt ſtones ; but, on a cloſer examination, ‘ they are, like the rocks of other mountains, ‘ compoſed of ſtrata of natural ſtones, of a ‘ cheſnut coloured earth, of chalk, and of white ‘ ſtones, which have not the ſmalleſt appear- ‘ ance of having been liquified by fire. . .

‘ Round Veſuvius we ſee openings which ‘ have been made at different times, and through ‘ which lavas had iſſued. Theſe torrents of burn‘ ing matter, which ſometimes come from the ‘ ſides, and ſometimes from the top of the ‘ mountain, deſcend into the plains, and ſome‘ times run as far as the ſea, and harden like a ‘ ſtone when the matter cools. . . .

‘ On the ſummit of Veſuvius there is only a ‘ ſmall margin of four or five palms wide, and ‘ deſcribes a circumference of 5624 Paris feet. ‘ Upon this margin we can walk pretty commo‘ diouſly. The whole of it is covered with ‘ burnt ſand, under which we find ſtones part‘ ly natural and partly calcined. . . . In ‘ two elevations on this margin, we find beds ‘ of natural ſtones, arranged in the ſame man‘ ner as in other mountains; which confutes ‘ the notion of thoſe who regard Veſuvius as a ‘ mountain gradually raiſed above the plain of ‘ the valley. . . .

‘ The depth of the gulf where the matter ‘ boils is about 543 feet; and the height of the ‘ mountain above the level of the ſea is 1677 ‘ feet, which is one third of an Italian mile.

‘ This height has been more conſiderable. ‘ The eruptions which have changed the ex‘ ternal form of the mountain, have likewiſe ‘ diminiſhed its elevation; for the parts they

‘ detached from the ſummit rolled into the ‘ gulf *.’

From all theſe examples, if we conſider the external figure of Sicily and other countries ravaged by fire, we ſhall evidently perceive that no volcano exiſts which is purely iſolated or detached. The ſurface of theſe countries every where preſents a ſucceſſion and ſometimes groups of volcano's. This we have already ſeen with regard to Ætna, and ſhall give a ſecond example of it in Hecla. A great part of the iſland, like Sicily, is only a group of volcano's, which I ſhall prove by the following obſervations.

The whole iſland ought be regarded as a vaſt mountain interſperſed with deep cavities, concealing in its bowels great quantities of minerals, vitrified and bituminous ſubſtances, and riſing from the midſt of the ſea in the form of a ſhort flattened cone. Its ſurface preſents to the eye nothing but tops of mountains covered with ſnow and ice; and lower down we have the picture of confuſion and ruin. It is an enormous maſs of ſtones and fragments of rocks, which are ſometimes porous and half calcined, and exhibit a hideous appearance by their blackneſs and the marks of fire impreſſed upon them. The fiſſures and hollows of rocks are filled with a red, and ſometimes with a black or

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* Hiſt. du Mont Veſuve, par le P. de la Torré; *Journal étranger, Janvier* 1756, *p.* 182.—208.

or white ſand: But, in the valleys between the mountains, we find agreeable plains*.

Moſt of Jokuts, which are mountains of a middle height, and overtopped by others of a greater elevation, are volcano's that occaſionally throw out flames, and produce earthquakes: Of theſe there are no leſs than twenty in this iſland. The inhabitants in the neighbourhood of theſe mountains have learned by experience and obſervation, that, when the ice and ſnow riſe to a conſiderable height, and ſtop the mouths of theſe cavities, which formerly diſcharged flames, that earthquakes are about to happen, which are always ſucceeded by eruptions of fire. It is for this reaſon that the Icelanders are at preſent afraid leſt the Jokuts, which, in the year 1728, threw out flames in the canton of Skaftfield, ſhould ſoon be again inflamed; the ice and ſnow being accumulated on their ſummits, and appearing to obſtruct thoſe vents which favoured the exhalations of the ſubterraneous fires.

In 1721, the Jokut called Koëtlegan, about five or ſix leagues to the weſt of the ſea, near the bay of Portland, broke out into flames, after ſeveral ſucceſſions of the earth. This conflagration melted maſſes of ice of an enormous thickneſs, and gave riſe to impetuous torrents, which deluged the country, and carried down to the ſea prodigious quantities of earth, ſand, and ſtones. The ſolid maſſes of ice, and the immenſe quantity of earth, ſtones, and ſand, tranſported by the inundation, ſo loaded the ſea, that, at half a mile from the coaſt, a ſmall mountain was formed, which ſtill appeared above the ſea in the year 1750. We may form ſome idea of the quantity of matter carried down to the ſea by this inundation, when we conſider that it was obliged to retreat twelve miles beyond its former limits.

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* Introd. a l'Hiſt. du Denemarck.

The inundation continued three days; and it was not till after this period that a perſon could paſs on foot to the mountains. . . .

Hecla, which has always been regarded as one of the moſt famous volcano's in the univerſe, on account of its tremendous eruptions, is now one of the leaſt dangerous in the iſland. Mounts Koëtlegan and Krafle have recently made as great ravages as Hecla did of old. It has been remarked, that this laſt volcano has thrown out flames ten times only in the ſpace of eight hundred years, namely, in the years 1104, 1157, 1222, 1300, 1341, 1362, 1389, 1558, 1636, and, laſtly, in the year 1693. This eruption commenced on the 13th of February, and continued to the month of Auguſt following. All the other eruptions laſted a few months only. From the above dates it appears, that Hecla made its greateſt ravages in the fourteenth century, having undergone no leſs than four eruptions; that it remained perfectly tranquil during the 15th century; and that it threw out no fire for one hundred and ſixty years. From this period, there was one eruption only in the ſixteenth, and two in the ſeventeenth century. We now perceive in this volcano neither fire, nor ſmoke, nor exhalations of any kind. We only find, in ſome ſmall hollows, as is common in many other parts of the iſland, boiling water, ſtones, ſand, and aſhes.

In 1726, after a few ſuccuſſions of the earth, which were felt only in the northern cantons, Mount Krafle began to throw out, with a dreadful noiſe, ſmoke, flames, aſhes and ſtones. This eruption continued two or three years, without doing any damage; becauſe the whole rejected matter fell back upon the mountain, or round its baſe.

In 1728, the fire communicated with ſome mountains ſituated near Krafle, which burnt during ſeveral weeks. When the minerals they contained were melted, a river of fire ran gently toward the ſouth into the country below theſe mountains. This river threw itſelf into a lake about three leagues from Mount Krafle, and, by the ſhock of the water, produced a horrible noiſe, and clouds of vapours. The running of the lava did not ceaſe till 1729, when the matter

ter which formed it was probably exhauſted. The lake was filled with an immenſe quantity of calcined ſtones, which raiſed its water conſiderably. It is about twenty leagues in circumference, and ſituated at an equal diſtance from the ſea. We ſhall not take notice of the other volcano's in this iſland; it is ſufficient that we have mentioned the moſt conſiderable of them *.

From this deſcription we perceive, that the Jokuts of Hecla greatly reſemble the ſecondary volcano's of Ætna; that, in both, the higheſt ſummit is tranquil; that the ſummit of Veſuvius is much ſunk; and that probably thoſe of Ætna and Hecla were formerly higher than they are at preſent.

Though the topography of volcano's in other parts of the world is not ſo well known as that of thoſe in Europe, we may, nevertheleſs, preſume, from analogy, and the ſimilarity of their effects, that they reſemble each other in every reſpect. They are all ſituated in iſlands, or upon the coaſts of continents. Almoſt the whole of them are ſurrounded with ſecondary volcano's. Some of them are active, and others extinguiſhed or quiet. The number of the latter is greater, even in the Cordelieres, which appear to be the moſt ancient domain of volcano's. In the ſouth of Aſia, the iſlands of Sonde, the Moluccas, and Philippines, bear evident marks of deſtruction

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* Hiſt. Gen. des Voyages, tom. 18. p. 9. 10. 11.

deſtruction by fire, and are ſtill infeſted with volcano's. They are likewiſe very frequent in the iſland of Japan: This country is alſo more ſubject to earthquakes than any other part of the globe. In many places of Japan there are hot fountains. Moſt of the Indian iſlands, and all the ſeas of theſe eaſtern regions, preſent to our eyes nothing but peaks and detached ſummits, which vomit out fire, and deep indented coaſts, the relicks of ancient continents which are now no more. Here the mariner often meets with ports which daily ſink; and even whole iſlands have been known to diſappear, and to be ſwallowed up, with their volcano's, by the waters. The ſeas in China are warm, which is a proof that there is a great effervescence in the maritime baſins of this region. The hurricanes are tremendous, and waterſpouts are frequent. The tempeſts are always preceded by general and perceptible boilings of the waters, and by various meteors and other exhalations with which the atmoſphere is loaded.

The volcano of Teneriff has been explored by Dr Thomas Heberden, who reſided ſeveral years in the village of Oratava, which is ſituated at the foot of the Peak. In his way he found large ſtones diſpoſed on all ſides at ſeveral leagues from the top of the mountain. Some of them appeared to be entire, and others ſeemed to have been burnt, and thrown to this diſtance by the volcano. In aſcending the mountain he ſtill ſaw burnt rocks ſcattered about in large maſſes.

'We arrived,' Dr Heberden remarks, 'at 'the famous grotto of Zegds, which is ſurrounded on all ſides with enormous maſſes of burnt 'rocks. . . . .

'A quarter of a league higher, we met with 'a ſandy plain, in the middle of which there is 'a pyramid of ſand, or yellowiſh aſhes, called 'the *Sugar Loaf*. Round its baſe, fuliginous 'vapours perpetually ariſe. From thence to the 'ſummit, the diſtance might be half a quarter of 'a league. But the aſcent is too difficult, on 'account of its ſteepneſs and the bad footing. . .

'However, we reached what is called the '*Cauldron* which is twelve or fifteen feet deep. 'Its ſides taper to the bottom, and form a cavity 'which reſembles a reverſed cone. . . . Here 'the ground is very warm; and, from about 'twenty tubes or chimneys, a thick ſulphureous 'vapour ariſes. The whole ground ſeems to be 'mixed with ſulphur, which gives the ſurface 'a brilliant appearance. . . . .

'Upon almoſt all the ſtones in the neighbourhood, we perceive a greeniſh colour, intermixed with yellow like gold. A ſmall part 'of this ſugar-loaf is as white as chalk; and another

‘ other part, ſtill lower, reſembles red clay co-‘ vered with ſalt. . . . .

‘ In the middle of another rock, we diſcover-‘ ed a hole, which exceeded not two inches in ‘ diameter, from whence proceeded a noiſe ſimi-‘ lar to that of a conſiderable quantity of water ‘ boiling over a great fire *.’

The Azores, the Canaries, the iſlands of Cape Verd, Aſcenſion iſland, and the Antilles, which appear to be the relicks of ancient continents that united the Old Continent with America, offer nothing to our obſervation but burnt lands, or lands which ſtill continue to burn. The volcano’s formerly ſunk under the waters with the countries which ſupported them, excite ſuch terrible tempeſts, that, in one of theſe ſtorms which happened at the Azores, the ſuet fixed to the end of the plumb-line melted by the heat at the bottom of the ſea.

III.

Of extinguiſhed Volcano’s.

THE number of extinguiſhed volcano’s exceed incomparably that of thoſe which are active. They

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[*] Obſervations on the Peak of Teneriff by Dr Heberden.

They are very numerous in almoſt every part of the earth. I might mention thoſe remarked by M. de la Condamine in the Cordelieres, and by M. Frenaye in St Domingo *, near Port-au-Prince, and thoſe of Japan and the other eaſtern and ſouthern iſlands of Aſia, the whole of which countries have been formerly ravaged by fire. But I ſhall limit myſelf to the extinguiſhed volcano's of the iſles of France and Bourbon, which have been recogniſed by ſome enlightened voyagers.

‘ The ſoil of the iſle of France,’ ſays M. l'Abbé de la Caille, ‘ is covered with a prodigious ‘ number of ſtones of all ſizes, which are of a ‘ blackiſh aſh-colour. Many of them are full ‘ of holes, like a ſieve. Moſt of them contain a ‘ great quantity of iron ; and the ſurface of the ‘ earth is covered with the ore of this metal. ‘ We likewiſe find, eſpecially on the north coaſt ‘ of the iſland, a great many pumice ſtones, lavas, ‘ or refuſe of iron, profound grottos, and other ‘ manifeſt veſtiges of extinguiſhed volcano's. . .

‘ The iſle of Bourbon,’ continues M. l'Abbé de la Caille, ‘ though larger than the iſle of France, ‘ is only a large mountain, ſplit as it were from ‘ its ſummit into three different parts. Its top is ‘ covered with wood, and inhabited ; and two ‘ thirds of its declivity, which extends as far as ‘ the

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* Note communicated to M. de Buffon, by M. Frenaye, March 10. 1777.

‘ the ſea, are cleared and cultivated. The reſt ‘ is covered with the lavas of a volcano, which ‘ burns ſlowly, and without any noiſe. It ſeems ‘ not to burn much, except during the rainy ‘ ſeaſons. . . . .

‘ Aſcenſion iſland has viſibly been formed ‘ and burnt by a volcano. It is covered with ‘ a red earth, ſimilar to brick-duſt or burnt ‘ clay. . . . . The iſland is compoſed of ſeveral ‘ mountains from 100 to 150 fathoms high. ‘ There is one ſtill larger to the ſouth of the ‘ iſland, which is about 400 fathoms in height. . ‘ Its ſummit is double and lengthened : But all ‘ the others are pretty perfect cones, and cover‘ ed with red earth. The land and part of the ‘ mountains are interſperſed with prodigious ‘ quantities of rocks full of holes, like ſieves, and ‘ with very light calcarious ſtones, a number of ‘ which reſembled coagulated milk ; ſome of ‘ them were laid over with a dirty white varniſh ‘ approaching to green. Pumice ſtones are like‘ wiſe very frequent †.’

The celebrated Captain Cook remarks, that, in an excurſion to the interior parts of Otaheite, they found burnt rocks, like thoſe of Madeira ; that all the ſtones bore inconteſtible marks of fire ; that they likewiſe perceived traces of fire in the clay upon the hills ; and that Otaheite and a number of adjacent iſlands might be ſuppoſed to be the relicks of a continent which had been ſwallowed by the exploſions of ſubterraneous fire [†]. Philip Carteret tells us, that one of the Charlotte iſlands, ſituated in the 11° 10′ of ſouth latude, is of a prodigious height and a conical figure; that its ſummit is like a funnel, from which ſmoke iſſues, but no flames; and that, on the moſt ſouthern coaſt of New Britain, there are three mountains, from one of which proceeds a large column of ſmoke [‡].

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† Mem. de l’Acad. des Sciences, année 1754, p. 111. 121. and 126.

We find baſalts in the iſle of Bourbon, where the volcano, though feeble, ſtill acts; in the iſle of France, where all the fires are extinct; and in Madagaſcar, where there are both active and extinguiſhed volcano's. But, to mention no other baſalts but thoſe of Europe, we know that there are conſiderable maſſes of them in Ireland, in Britain, in Auvergne, upon the borders of the Elbe, in Miſnia upon Mount Cattener, at Marienburg, at Weilbourg in the county of Naſſau, at Lauterback, at Billſtein, in ſeveral parts of Heſſe, in Luſace, in Bohemia, &c. Theſe baſalts are moſt beautiful lavas produced in all theſe countries, by volcano's which are now extinct. But we ſhall content ourſelves with abridged deſcriptions of extinguiſhed volcano's in France.

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[†] Cook's voyage, tom. 2. p. 431.

[‡] Carteret's voyage, p. 250. and 275.

‘ The mountains of Auvergne,’ ſays M. Guettard, ‘ which have formerly, in my eſtimation, ‘ been volcano’s . . . . . are thoſe of Volvic two ‘ leagues from Riom, of Puy-de-dôme near Clermont, and of Mount Or. The volcano of Volvic has formed, by its different lavas, ſtrata lying upon each other, and compoſing enormous ‘ maſſes, in which quarries are dug, and furniſh ‘ ſtones to ſeveral places at a diſtance. . . . . It ‘ was at Moulins where I firſt diſcovered lava. . . ‘ and being at Volvic, I perceived that the ‘ mountain was almoſt entirely compoſed of ‘ matters which had been thrown out by the eruptions of volcano’s.

‘ The figure of this mountain is conical, and ‘ its baſe conſiſts of rocks of a grayiſh white granite, or of the colour of a pale roſe. . . . The ‘ reſt of the mountain is compoſed entirely of ‘ blackiſh or reddiſh pumice ſtones, heaped upon ‘ each other without order or connection. . . . . ‘ About two thirds up the mountain, we meet ‘ with irregular rocks, briſtled with miſhapen ‘ points turned to all ſides, and of an obſcure red ‘ or dirty black. They are ſolid and hard, and ‘ have no holes, like the pumice ſtones. . Before ‘ arriving at the ſummit, we find a hole of ſome ‘ fathoms wide, and of a conical figure, approaching to that of a funnel. . . . The part of the ‘ mountain to the north and eaſt, appeared to be ‘ ſolely compoſed of pumice ſtones. . . . . . In

'Volvic, the beds of ſtone follow the inclination 'of the mountain, and ſeem to be continued 'through it, and to communicate with thoſe diſ'covered by the ravines a little below the ſum'mit. . . Theſe ſtones are of an iron gray co'lour, and ſeem to have a white grain, which 'comes out on the ſurface like an efflorefcence: 'Though ſpongy, and full of ſmall irregular 'holes, they are hard.

'Mount-puy-de-dôme is nothing but a maſs 'of matter which indicates the dreadful effects 'of the moſt violent fire. . . . In thoſe places 'of the mountain which are not covered with 'plants and trees, we travel among pumice 'ſtones, pieces of lava, and a gravel or ſand, 'formed by a kind of iron droſs and ſmall bits 'of pumice-ſtones mixed with aſhes.

'Theſe mountains exhibit ſeveral peaks, and 'all of them have cavities or funnels of greater 'or ſmaller dimenſions. One of theſe peaks, the 'road which leads to it, and the whole ſpace as 'far as Puy-de-dôme, are only vaſt heaps of 'pumice-ſtones. The ſame obſervation is ap'plicable to the other peaks, which are fifteen 'or ſixteen in number, ſituated in the ſame line 'from ſouth to north, and all of them furniſh'ed with funnels.

'The top of the peak of Mount Or is a rock 'compoſed of a tender whitiſh aſh-coloured 'ſtone, ſimilar to that on the ſummits of all the 'mountains in this volcanic country: It is only a little lighter than that of Puy-de-dôme.

'If I found not on this mountain as many 'veſtiges of a volcano as in the other two, it 'muſt be partly aſcribed to this circumſtance, 'that Mount Or is more covered, through its 'whole extent, with trees and ſhrubs, than 'Mounts Volvic and Puy-de-dôme. . . . However, the ſouth-eaſt part is entirely bare, and 'entirely compoſed of ſtones and rocks, which 'ſeem to have been exempted from the effects 'of the fire. . . . .

'But the peak of Mount Or is a cone ſimilar 'to thoſe of Volvic and Puy-de-dôme. To the 'eaſt of this point is the Peak du Capuchin, 'which is likewiſe conical, but not ſo regular as 'thoſe of the preceding mountains. It even 'appears that this peak has undergone more 'changes in its ſtructure; for every thing is more 'irregular, and broken into ſmaller portions. . . 'There are ſtill ſeveral other peaks, the baſes of 'which reſt upon the ridge of the mountain; but 'they are all overtopped by Mount Or, which 'is 509 fathoms high. . . . The peak of Mount 'Or is very rugged: It terminates in a point about fifteen or twenty feet in diameter. . . .

'There are ſeveral conical mountains between 'Thiers and Saint Chaumont, which led me to 'think,' ſays M. Guettard, 'that they might 'have been burnt. . . . Though I have never 'been at Pontgibault, I have ſufficient proofs to 'convince me that the mountains of this canton 'are extinguiſhed volcano's; I have received 'fragments of lava from them, which it was 'eaſy to recogniſe by the yellow and blackiſh 'points of vitrified matter, which are the moſt 'certain characteriſtics of volcanic produc'tions *.'

The ſame M. Guettard and M. Faujas have found, on the left bank of the Rhone, and a good way into the country, very large fragments of baſaltic columns. . . . In aſcending into the Vivarais, they found in a rapid brook a vaſt collection of volcanic matter, which they followed to its ſource. It was not difficult to recogniſe the volcano. It is a very high mountain, on the top of which they found a mouth of about 80 feet in diameter. Below this mouth the lava is partly viſible. It has flowed down the ravines in great maſſes, for the ſpace of ſeven or eight thouſand fathoms. The matter has heaped together while yet burning in certain places; and, after fixing, it chapped and ſplit through its whole thickneſs, and left the whole plain covered with innumerable columns, from fifteen to thirty feet long by about ſeven inches in diameter †.

'Having

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* Mem. de l'Acad. des Sciences, année 1752, p. 27.—58.

† Journal de Phyſiques, par M. l'Abbé Rozier; *Mois de Decembre* 1775, *p.* 516.

‘ Having proceeded to Montferrier,’ ſays M. Montet, ‘ a village about a league diſtant ‘ from Montpelier. . . . . I found a number ‘ of black ſtones, detached from each other, and ‘ of different figures and ſizes. . . . . I compa‘ red them with others which were unqueſtion‘ ably the production of volcano’s, . . . and found ‘ them to be of the ſame nature. Hence I no ‘ longer doubted that theſe ſtones of Montferrier ‘ were a very hard lava, or a matter melted by ‘ a volcano, which had long been extinguiſhed. ‘ The whole mountain of Montferrier is inter‘ ſperſed with theſe ſtones, and the ſtreets are ‘ paved and the village partly built with them. ‘ . . . The ſurfaces of theſe ſtones are, in ge‘ neral, full of holes or poroſities, which ſuf‘ ficiently indicate that they have been formed ‘ of matter melted by a volcano. This lava is ‘ diſperſed over all the grounds adjacent to Mont‘ ferrier. . . .

‘ On the ſide of Pézenas, extinguiſhed volca‘ no’s are very numerous . . . . The whole ‘ country is full of them, eſpecially from Cap ‘ d’Agde, which itſelf is an extinguiſhed volca‘ no, to the foot of that chain of mountains ‘ that commences five leagues to the north of ‘ this coaſt, and upon their declivity, or at a ‘ little diſtance from them, are ſituated the vil‘ lages of Livran, Peret, Fontés, Néſiez, Gabi‘ an, and Faugéres. In going from ſouth to [illegible] 'north, we find a remarkable plinth or chaplet, 'which begins at Cap d'Agde, and comprehends 'Mounts Saint-Thibery, and Cauſſe, (mountains 'ſituated in the middle of the plains of Breſſan), 'the peak of Valros in the territory of this village, the peak of Montredon in the territory 'of Tourbes, and that of Saint-Marthe, near 'the royal Priory of Caſſan. Beſides, from the 'foot of the mountain, a great and long maſs 'ariſes, and terminates to the ſouth near the 'Grange of Prés, and from eaſt to weſt between 'the village of Caus and that of Nizas. . . . . It 'is to be remarked of this canton, that it conſiſts of almoſt nothing but a maſs of lava, and 'that in the middle of it there is a round mouth 'or diſtinct crater about 200 fathoms in diameter, which formed a pond that has ſince been 'drained by a deep cut through the hard lava, 'which is diſpoſed into ſtrata, or rather contiguous undulations. . . . .

'In all theſe places we find lava and pumice 'ſtones. Almoſt the whole village of Pezenas 'is paved with lava. The rock of Agde is nothing but a hard lava, and the whole of this 'village is built and paved with this lava, which 'is very black. . . . . Almoſt the whole territory 'of Gabian, in which is the famous fountain of 'Petroleum, is beſtrewed with lava and pumice-'ſtones.

'We likewiſe find at Cauſſe, Baſan, and

'Saint-Thibery, a conſiderable quantity of baſalts, which are commonly priſms with ſix ſides, and from ten to fourteen feet in length. These baſalts are found in a place where the veſtiges of an ancient volcano are no longer recogniſable.

'The baths of Balaruc every where preſent us with relicks of an extinguiſhed volcano. The ſtones found there are nothing but pumices of different ſizes. . . .

'In all the volcano's I examined, I remarked, that the matter or ſtones thrown out are of various figures. Some of them are in large, heavy, and hard maſſes, like the rock of Agde: Others, like thoſe of Montferrier and the lava of Tourbes, are in detached pieces of conſiderable weight and hardneſs*.'

M. Villet, of the academy of Marſeilles, has tranſmitted to the king's cabinet ſome ſpecimens of lava and other matters found in the extinguiſhed volcano's of Provence; and he writes me, that, a league from Toulon, there are evident veſtiges of an ancient volcano; and that, having deſcended a ravine to the foot of this old volcano of Mount d'Ollioules, he was ſtruck with the appearance of a detached rock which had come down from the mountain. It was calcined; and, having broke off ſome pieces, he found in the heart ſome ſulphureous particles ſo ſtrongly marked, that he no longer doubted the ancient exiſtence of theſe volcano's which are now extinct*.

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* Mem. de l'Acad. des Sciences, année 1760, p. 466.—473.

M. Valmont de Bomare has obſerved, in the territory of Cologne, the veſtiges of ſeveral extinguiſhed volcano's.

I could give many other examples, which all concur in proving, that the number of extinguiſhed volcano's is perhaps a hundred times greater than that of thoſe now actually exiſting. I muſt here remark, that, between theſe two, there are, as in all the other operations of Nature, intermediate ſtates, degrees, and ſhades, of which we can only lay hold of the principal traits. For example, the Solfataras are neither active nor extinguiſhed volcano's, but ſeem to participate of both. Theſe no man has better deſcribed than one of our learned Academicians, M. Fougeroux de Bondaroy; I ſhall, therefore, lay before the reader his chief obſervations.

'Solfatara, ſituated four miles weſt from Naples, and two miles from the ſea, is ſurrounded on all ſides with mountains. Before arriving at it, we muſt aſcend about half an hour. The ſpace compriſed between the mountains forms a baſin of about 1200 feet in length by 800 feet broad. With regard to the mountains,

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* Lettre de M. Villet a M. de Buffon; *Marſeille, le* 8. Mai 1775.

‘ tains, it lies in a bottom; but it is not ſo low
‘ as the ground you traverſe in going to it.
‘ The ſoil in the bottom of the baſin is a very
‘ fine, cloſe, beaten ſand, and it is ſo dry and
‘ parched that it produces no vegetables. The
‘ colour of the ſand is yellowiſh. . . . The ſul-
‘ phur, which is found in great quantities among
‘ the ſand, gives it this colour. The mountains
‘ which bound the greateſt part of the baſin
‘ conſiſt of bare rocks, without earth or plants.
‘ Some of them are ſplit, and their parts are
‘ burnt and calcined; but the whole preſent no
‘ arrangement or order in their poſition. . . . .
‘ They are covered with greater or ſmaller quan-
‘ tities of ſulphur, which is ſublimed in this part
‘ of the mountain and in the neighbouring baſin.

‘ The oppoſite ſide conſiſts of a better ſoil. . .
‘ Neither does it preſent furnaces ſimilar to thoſe
‘ formerly mentioned, and which are common
‘ on the other ſide.

‘ In ſeveral places, we find, in the bottom of
‘ the baſin, apertures or mouths, from which
‘ iſſues ſmoke, accompanied with a heat that
‘ would burn the hands ſmartly; but it is not
‘ ſtrong enough to kindle paper. . . .

‘ The adjacent places produce a heat which
‘ is felt through the ſhoes, and a diſagreeable
‘ odour of ſulphur exhales from them. . . When
‘ a ſharp pointed ſtick is thruſt into the ground,

'there ſoon iſſues a vapour or ſmoke, ſimilar to 'that which exhales from the natural crevices.

'Through theſe apertures, a ſmall quantity 'of ſulphur is ſublimed, together with a ſalt 'which has all the characters of ſal ammoniac.

'On ſeveral ſtones which ſurround Solfatara, 'we find threads of allum. . . . Laſtly, ſulphur 'is collected from Solfatara. . . . This ſubſtance 'is extracted from grayiſh ſtones, interſperſed 'with ſhining particles, which are ſulphur cry'ſtallized between the ſtony particles. . . Theſe 'ſtones are ſometimes impregnated with allum.

'By ſtriking the middle of the baſin with 'our foot, we eaſily perceive that the ground is 'hollow below.

'If we traverſe the ſide of the mountain, 'where the mines are moſt numerous, we find 'lavas, pumice-ſtones, the droſs of volcano's, '&c. In a word, the whole appearances, when 'compared with the matters at preſent furniſh'ed by Veſuvius, demonſtrate that Solfatara was 'formerly the mouth of a volcano. . . .

'The baſin of Solfatara has often changed 'its form; and we may conjecture that it will 'ſtill aſſume others. This territory daily hol'lows and undermines itſelf. It at preſent 'forms a vault which covers an abyſs. . . . If 'this vault ſinks, the abyſs will probably fill 'with water and produce a lake *.'

M.

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* Mem. de l'Acad. des Sciences, année 1765, p. 267.—283.

M. Fougeroux de Bonderoy has likewiſe made ſome obſervations on Solfataras in other parts of Italy.

‘ I have been,’ ſays he, ‘ at the ſource of a ‘ rivulet, which we paſs in the road between ‘ Rome and Tivoli, the water of which has a ‘ ſtrong odour of liver of ſulphur. . . . . ‘ It forms two ſmall lakes, about forty fathoms ‘ in their greateſt extent. . .

‘ One of theſe lakes, according to the plumb-‘ line we were obliged to uſe, was, in different ‘ places, 60, 70, and 80 fathoms deep. . . In ‘ theſe lakes we ſaw ſeveral floating iſlands, ‘ which ſometimes change their ſituation. . . . ‘ They are compoſed of plants reduced into a ‘ kind of light turf, upon which the waters, ‘ though corroſive, have no effect. . . .

‘ The heat of theſe waters was 20 degrees, ‘ when the thermometer in the open air ſtood at ‘ 18 degrees. Thus it appears from experiment, ‘ that the heat of theſe waters is inconſiderable. . ‘ They exhale a diſagreeable odour; and this ‘ vapour changes the colour of vegetables and ‘ of copper *.’

‘ The Solfatara of Viterbe,’ M. l’Abbé Mazeas remarks, ‘ has a mouth of from three ‘ to four feet only. Its waters boil, exhale an ‘ odour of the liver of ſulphur, and petrify ‘ their canals, like thoſe of Tivoli. . . The de-‘ gree

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* Mem. de l’Acad. des Sciences, année 1770, p. 1—7

'gree of their heat is that of boiling water, 'and ſometimes more.' . . The volumes of 'ſmoke, which ſometimes ariſe, indicate a ſtill 'greater heat; and yet the bottom of the baſin 'is covered with plants which grow in the 'bottom of the lakes, and in the marſhes. 'In ferruginous ſoils, theſe waters produce vi- 'triol,' &c. †.

'In ſeveral of the Apennine mountains, and 'particularly in thoſe on the road from Bologna 'to Florence, we find fires, or vapours which re- 'quire only the approach of a candle to inflame 'them. . . .

'The fires of Mount Cenida, near Pietramala, 'are ſituated at different heights of the moun- 'tain, upon which we find four mouths that 'throw out flames. . . . One of theſe fires is 'in a circular place ſurrounded with a riſing 'ground. . . . Here the earth appears to be 'burnt, and the ſtones are blacker than thoſe 'in the neighbourhood; there likewiſe iſſues, 'here and there, a lively, blue, clear flame, 'which riſes from three to four feet high. . . . 'But, beyond this circular ſpace, we ſee no fire, 'though the heat of the ground is perceptible 'at the diſtance of ſixty feet from the centre 'of theſe flames. . . .

'Along a fiſſure or crevice in the neighbour- 'hood of the fire, we hear a dull noiſe, like that of

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† Mem. des Savans étrangers, tom. 5. p. 325.

‘ wind moving through a ſubterraneous paſſage. ‘ Near this place, we find two ſources of hot ‘ water. . . The ground, in which fire has long ‘ exiſted, is neither depreſſed nor elevated. . . ‘ Near this fire we ſee no volcanic ſtones, nor ‘ any mark which indicates that fire has ever ‘ been thrown out. However, ſome little hills ‘ in the neighbourhood have every appearance ‘ of having been formed, or at leaſt changed ‘ by volcano's. . . . In 1767, ſuccuſſions of an ‘ earthquake were felt in the environs; but ‘ no change was produced on the fire, neither ‘ was the ſmoke increaſed or diminiſhed. . .

‘ About ten leagues from Modena, at a ‘ place called *Barigazzo*, there are five or ſix ‘ openings where, at particular times, flames ap‘pear, which are extinguiſhed by a ſtrong ‘ wind: There are likewiſe vapours which in‘flame by contact with fire. . . . But, notwith‘ſtanding the unequivocal veſtiges of extin‘guiſhed volcano's which ſubſiſt in moſt of theſe ‘ mountains, the fires ſeen there are not new ‘ volcano's forming, becauſe they never throw ‘ out any volcanic matter *.’

Hot waters, as well as the fountains of Petroleum, and other bituminous and oily ſubſtances, ſhould be regarded as another ſhade between extinguiſhed and active volcano's.

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* Mem. ſur le Pétrole, par M. Fougeroux de Banderoy, dans ceux de l'Acad. des ſciences, année 1770, p. 45.

When ſubterraneous fires exiſt near ſtrata of coal, they diſſolve the coal, and give riſe to moſt ſources of bitumen : They likewiſe occaſion the heat of the hot ſprings which run in their neighbourhood. But theſe ſubterraneous fires now burn with tranquility ; and we only recogniſe their ancient exploſions by the ſubſtances they have formerly rejected. They ceaſed to act when the ſea retired from them ; and, as already remarked, I believe there is no longer any reaſon to dread the return of theſe direful exploſions, ſince every obſervation concurs in ſhowing that the ſea will always retire farther and farther.

IV.

Of Lavas and Baſalts.

To what we have ſaid on the ſubject of volcano's, we ſhall add ſome remarks on the motion of lavas, and on the time neceſſary for their cooling and their converſion into vegetable ſoil.

The lava which runs from the foot of the eminences formed by the matters rejected by the volcano, is an impure glaſs in fuſion. It is a tenacious, viſcous, and half fluid ſubſtance.

Hence the torrents of this vitrified matter, when compared to torrents of water, run ſlowly; and yet they often proceed to great diſtances. In theſe torrents of fire, however, there is another movement than what takes places in thoſe of water: This movement tends to elevate the whole running maſs, and is produced by the expanſive force of the heat in the interior parts of the burning torrent. The external ſurface cools firſt; the liquid fire continues to run below; and, as heat acts equally on all ſides, the fire, which endeavours to eſcape, elevates the ſuperior parts that are already conſolidated, and often forces them to riſe perpendicularly. This is the origin of thoſe large maſſes of lava in the form of rocks, which are found in the courſe of almoſt every torrent where the declivity is not great. By the efforts of this internal heat, the lava makes frequent exploſions; its ſurface opens, and the liquid matter ſprings up and forms thoſe maſſes which we ſee elevated above the level of the torrent. Le P. de la Torré, I believe, is the firſt perſon who obſerved this internal movement of burning lavas, which is always more violent in proportion to their thickneſs and the gentleneſs of the declivity. This effect is common to all matters liquified by fire, and every man may ſee examples of it in our common founderies *. If

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* The lava of iron founderies exhibits the ſame effects. When this vitreous matter runs ſlowly, and accumulates at the

If we obſerve thoſe large ingots or maſſes of melted iron, which run in a mould or canal with a very ſmall declivity, we ſhall perceive that they have a tendency to riſe like arches, eſpecially when the ſtream is very thick *. We have formerly ſhewn, by experiments, that the time of conſolidation is always proportioned to the thickneſs of the ingots, and that, when their ſurfaces are hardened, the interior parts ſtill continue to be liquid. It is this internal heat which elevates the ingots and makes them bliſter. If their thickneſs were greater, there would be produced, as in the torrents of lava, exploſions, rup-

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the baſe, we ſee eminences ariſe, which are bubbles or concave hemiſpheres of glaſs. Theſe bubbles increaſe, when the expanſive force is great, and the matter has little fluidity: It then ſuddenly explodes into a flame, and makes a conſiderable report. When the liquified matter is ſufficiently adheſive to ſuffer a great dilatation, theſe ſuperficial bubbles acquire a volume of eight or ten inches in diameter, without breaking. When the vitrification is leſs complete, and the matter is viſcous and tenaceous, the bubbles are ſmaller, and in cooling form concave eminences called *toad's eyes*. What happens in miniature in our founderies, is likewiſe exhibited upon a larger ſcale in the lavas of volcano's.

* I have not mentioned ſome particular cauſes which frequently produce a curvature or ſwelling in our melted ingots: For example, when the matter is not very fluid, or when the mould is too moiſt, the ingots bend conſiderably; becauſe theſe cauſes concur in augmenting the effect of the firſt. Thus the humidity of the ground, on which the torrents of lava deſcend, and the internal heat concur in raiſing the maſs, and in producing exploſions, which are always accompanied with thoſe jets of matter formerly mentioned.

tures in the ſurface, and perpendicular jets of metallic mater puſhed out by the action of the fire incloſed in the interior parts of the ingots. This explication, drawn from the nature of the thing itſelf, leaves no doubt concerning the origin of thoſe eminences ſo frequent in valleys and plains, which have been over-run or covered with lava.

When, after deſcending from the mountain and traverſing the fields, the burning lava arrives at the margin of the ſea, its courſe is ſuddenly interrupted, the torrent advances, and, like a powerful enemy, makes the water at firſt retire: But the water, by its immenſity, by the reſiſtance of its cold, and by its power of arreſting and extinguiſhing fire, ſoon conſolidates the torrent of burning matter, which can now proceed no farther, but riſes up, accumulates new ſtrata, and forms a perpendicular wall, from the top of which the lava falls and applies itſelf to the face of the wall thus formed. It is this falling and arreſting of the burning matter that gives riſe to baſaltic priſms * and their jointed columns. Theſe priſms have generally five, ſix, or ſeven ſides, ſometimes only three or four, and

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* I ſhall not here inquire into the origin of the term *baſalt*, which M. Deſmarets of the academy of Sciences, a learned naturaliſt, believes to have been applied by the ancients to different kinds of ſtones; but ſhall limit myſelf to the *baſaltic lava*, which appears under the form of priſmatic columns.

and ſometimes eight or nine. The baſaltic columns are formed by the perpendicular fall of the lava into the ſea, whether it falls from high rocks on the ſhore, or from a wall raiſed by its own accumulations. In both caſes, the cold and humidity of the water arreſt the burning matter, and conſolidate its ſurfaces the moment it falls; and the ſucceſſive bundles or maſſes of lava apply themſelves to each other. As the internal heat of theſe maſſes tends to dilate them, a reciprocal reſiſtance is created; and the ſame effect is produced as happens in the ſwelling of peaſe, or rather of cylindrical grain, when ſqueezed in a cloſe veſſel filled with boiling water. Each of theſe grains would aſſume a hexagonal figure by reciprocal compreſſion. In the ſame manner, each bundle or maſs of lava aſſumes ſeveral ſides by dilatation and reciprocal reſiſtance; and, when the reſiſtance of the ſurrounding bundles is ſtronger than the dilatation of the bundle ſurrounded, inſtead of becoming hexagonal, it has only three, four, or five ſides. But, if the dilatation of the ſurrounded bundle is ſtronger than the reſiſtance of the ſurrounding bundles, it aſſumes ſeven, eight, or nine ſides, which are always longitudinal.

The tranſverſe articulations of theſe priſmatic columns are produced by a cauſe ſtill more ſimple: The bundles of lava fall not in a regular and continued ſtream, nor in equal maſſes.

Hence,

Hence, if there are intervals in the fall of the matter, the ſuperior ſurface of the forming column being partly conſolidated, is hollowed by the weight of the ſucceeding maſs, which then moulds itſelf into a convex form in the concavity or depreſſion of the firſt. This is the productive cauſe of thoſe joints or articulations which appear in the greater part of priſmatic columns. But, when the lava falls in an uninterrupted ſtream, then the baſaltic column is one continued maſs, without any articulations. In the ſame manner, when, by an exploſion, ſome detached maſſes are darted from the torrent of lava, theſe maſſes aſſume a globular or elliptical figure, and are even ſometimes twiſted like cables. To this ſimple explication, all the forms of baſalts and figured lavas may be eaſily referred.

It is to the rencounter of lava with the waves, and its ſudden conſolidation, that the origin of theſe bold coaſts, which border all the ſeas at the foot of volcanic mountains, is to be aſcribed. The ancient ramparts of baſalt found in the interior parts of continents, ſhow that the ſea has been in the neighbourhood of theſe volcano's when they had thrown out lava. This is an additional proof of the ancient abode of the waters upon all the lands now inhabited.

The torrents of lava are from a hundred to two and three thouſand fathoms broad, and ſometimes one hundred and fifty, and even two hundred feet thick: And, as we have found by experience, that the time of the cooling of glaſs is to that of the cooling of iron as 132 to 236, and that the times of their reſpective conſolidation are nearly in the ſame proportion, it is eaſy to infer, that, to conſolidate the thickneſs of ten feet of glaſs or lava, 201 $\frac{21}{59}$ minutes would be neceſſary, ſince it requires 360 minutes to conſolidate ten feet thick of iron, conſequently it will require 4028 minutes, or 67 hours 8 minutes, to conſolidate 200 feet thick of lava: By the ſame rule we ſhall find, that 30 days $\frac{17}{24}$, or a month, will be requiſite before the ſurface of this lava of two hundred feet thick be ſufficiently cold to admit of being touched. Hence a year will be neceſſary to cool a lava of two hundred feet thick, ſo as to admit of being touched, without burning, at the depth of one foot; and, at ten feet deep, it will be ſtill ſo warm, at the end of ten years, as not to be tangible; and a hundred will be requiſite to cool it to the ſame degree in the middle of its thickneſs. Mr Brydone relates, that, more than four years after the lava had flowed, in the year 1766, at the foot of Ætna, it was not perfectly cool. Maſſa, a Sicilian author worthy of credit, tells us, 'that, being at Catania, eight years after the 'great eruption in 1669, he found, that the 'lava in ſeveral places was not entirely 'cool *.'

About

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* Voyage an Sicile, tom. i. p. 213.

About the end of April 1771, Sir William Hamilton dropt pieces of dry wood into a crevice in the lava at Veſuvius, and they were inſtantly inflamed: The lava iſſued from the mountain on the 19th of October 1767, and had no communication with the fire of the volcano. The place where this experiment was made, was at leaſt four miles diſtant from the mouth from which the lava iſſued. He is firmly perſuaded, that many years are neceſſary to cool a lava of this thickneſs (about 200 feet).

I have had no opportunity of making experiments upon conſolidation and cooling, but with balls of ſome inches in diameter. The only method of making experiments on a larger ſcale would be, to obſerve lavas, and to compare the times exhauſted in their conſolidation and cooling, according to their different thickneſſes. I am ſatisfied that theſe obſervations would confirm the law I have eſtabliſhed for the cooling of bodies from the ſtate of fuſion to the common temperature; and although theſe new obſervations are by no means neceſſary to ſupport my theory, ſtill they would help to fill up that immenſe gap between a cannon-ball and a planet.

It now remains for us to examine the nature of lava, and to ſhow, that, in time, it is converted into fertile earth; which recals the idea of the firſt converſion of the ſcoriae of the primitive glaſs that covered the whole ſurface of the globe after its conſolidation.

‘ Under the denomination of lava, we com-‘ prehend not,’ ſays M. de la Condamine, ‘ all ‘ the matter thrown out by a volcano, ſuch ‘ as aſhes, pumice-ſtones, gravel, and ſand ; but ‘ ſolely thoſe reduced to a liquid ſtate by the ‘ action of fire, and which, by cooling, form ‘ ſolid maſſes, whoſe hardneſs ſurpaſſes that ‘ of marble. This reſtriction notwithſtanding, ‘ many other ſpecies of lava may be conceived, ‘ according to the different degrees of fuſion ‘ in the mixture, the greater or ſmaller quanti-‘ ty of metal, and its greater or leſſer intimate ‘ union with the various matters. Beſide many ‘ intermediate kinds, three ſpecies are eaſily ‘ diſtinguiſhable. The pureſt lava reſembles, ‘ when poliſhed, a ſtone of an obſcure dirty ‘ gray colour. It is ſmooth, hard, heavy, and ‘ interſperſed with ſmall particles ſimilar to ‘ black marble, and whitiſh points. It ſeems ‘ to contain metallic particles. At firſt ſight, ‘ it reſembles ſerpentine, when the colour of ‘ the lava does not tend to green. It re-‘ ceives a pretty fine poliſh, which is more ‘ or leſs vivid in different parts. It is made ‘ into tables, chimney-pieces, &c.

‘ The coarſeſt kind of lava is rugged and un-‘ even. It reſembles the ſcoriae or droſs of ‘ iron. The moſt common ſpecies holds a ‘ middle rank between the two extremes :

‘ It is that which we every where find in large ‘ maſſes upon the ſides of Veſuvius and in ‘ the adjacent fields, where it has run in torrents. ‘ In cooling, it has formed maſſes ſimilar to ‘ ferruginous and ruſty rocks, which are often ‘ many feet thick. Theſe maſſes are frequently ‘ interrupted and covered with aſhes and ‘ calcined matter. . . . . It is under ſeveral ‘ alternate ſtrata of lava, aſhes, and earth, the ‘ whole of which forms a cruſt of from 60 ‘ to 80 feet thick, that temples, porticos, ſtatues, ‘ a theatre, and an entire city have been ‘ diſcovered *.

M. Fougeroux de Bondaroy remarks, ‘ that, ‘ immediately after an eruption of burnt earth ‘ or of a kind of aſhes, Veſuvius generally ‘ throws out lava, which runs down the fiſſures ‘ or furrows made in the mountain. . .

‘ The mineral matter inflamed, melted, and ‘ flowing, or lava properly ſo called, iſſues through ‘ cracks or crevices with more or leſs impetuoſity, ‘ and in greater or ſmaller quantity, according ‘ to the violence of the eruption. It ſpreads ‘ to a greater or ſmaller diſtance, according to ‘ the degree of fluidity, and the declivity of the ‘ mountain, which more or leſs retards its cooling. . .

‘ That which now covers a part of the land ‘ at

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* Mem. de. l’Acad. des Sciences, année 1757, p. 374.

'at the foot of the mountain, and which ſome-
'times ſtretches as far as Portici, conſiſts of
'large heavy maſſes, briſtled with points on
'their upper ſurface. The ſurface which reſts
'on the ground is flatter: As theſe pieces lie
'above each other, they have ſome reſemblance
'to the waves of the ſea. When the pieces are
'larger and more numerous, they aſſume the
'figure of rocks. . . .

'In cooling, the lava affects various forms. .
'The moſt common is that of tables or boards
'of greater or ſmaller dimenſions. Some pie-
'ces are ſix, ſeven, and eight feet long. It
'breaks into this form in cooling and conſoli-
'dating. This is the ſpecies of lava which is
'briſtled with points. . .

'The ſecond ſpecies reſembles great ropes:
'It is always found near the mouth of the
'volcano, and appears to have been ſuddenly
'fixed, and to have rolled before it hardened.
'It is lighter, more brittle, more bituminous,
'and ſofter, than the firſt ſpecies. By break-
'ing it, we likewiſe perceive that its ſubſtance
'is not ſo cloſe and compact. . .

'At the top of the mountain, we find a third
'ſpecies of lava, which is brilliant, and com-
'poſed of threads which ſometimes croſs one an-
'other. It is coarſe, and of a reddiſh violet co-
'lour. . . . Some fragments are ſono-
'rous, and have the figure of ſtalactites. . .

‘ Laſtly, in certain parts of the mountain, we ‘ find lavas of a ſpherical form, and appear to have ‘ been rolled. It is eaſy to conceive how the ‘ figures of theſe lavas might be varied by a ‘ number of accidental circumſtances *,’ &c.

Matter of every kind enters the compoſition of lavas. Iron and a ſmall quantity of copper have been extracted from the lava found on the ſummit of Veſuvius. Some ſpecimens are ſo impregnated with metallic ſubſtances as to preſerve the flexibility of metal. I have ſeen two large tables of lava of two inches thick, which were poliſhed like marble, and bended with their own weight. I have ſeen others, which were bended by a weight, and reſumed their horizontal poſition by their own elaſticity.

All lavas, when reduced to powder are, like glaſs, ſuſceptible of being converted, by the intervention of water, firſt into clay, and afterwards, by the mixture of duſt and corrupted vegetables, into excellent ſoil. Theſe facts are apparent from the vaſt and beautiful foreſts which ſurround Ætna, and grow upon a bottom of lava covered with ſeveral feet of good earth: The aſhes are more quickly converted into earth than the powder of glaſs or of lava. In the craters of old extinguiſhed volcano’s, as well as on the ancient rivers of lava, we find very fertile ſoils. Hence the devaſtations occaſioned by volcano’s are limited by time;

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* Mem. de l’acad. des Sciences, anneé 1766 p. 75.

time; and, as Nature is always more diſpoſed to produce than to deſtroy, ſhe, in a few ages, repairs the devaſtations of fire, and reſtores to the earth its former fertility by the very ſame materials ſhe had employed for the purpoſes of deſtruction.

ADDITIONS to the Article, Of Caverns, Vol. I. p. 442.

Of Caverns formed by the Primitive Fire.

IN my theory of the Earth, I mentioned only two kinds of caverns, the one produced by the fire of volcano's, and the other by the motion of ſubterraneous waters. Thoſe two ſpecies of caverns are not ſituated at great depths. They are even new, when compared with thoſe vaſt cavities, which were formed at the time the globe firſt aſſumed a ſolid form; for, at this period, all the ſuperficial eminences and hollows, and all the cavities in the interior parts of the earth, eſpecially near the ſurface, were produced. Several of thoſe caverns produced by the primitive fire, after being ſupported for ſome time, have afterwards ſplit by cooling, which diminiſhes the volume of every kind of matter; theſe would ſoon fall in, and, by their ſinking, form baſins or reſervoirs for the ſea, into which the waters, formerly much elevated above this level, ran, and abandoned the lands which they originally covered. It is more than probable, that a certain number of theſe ancient caverns ſtill ſubſiſt in the interior parts of the globe, and by their ſinking may produce ſimilar effects, and give riſe to new receptacles to the waters. In this caſe, they will partly abandon the baſin which they now occupy, and run, by their natural propenſity, into theſe lower places. For example, we find beds of ſea ſhells in the Pyrenees 1500 fathoms above the preſent level of the ocean. Hence it is certain, that the waters, when theſe ſhells were formed, roſe 1500 fathoms higher than they do at preſent. But, when the caverns, which ſupported the lands that are now the bed of the Atlantic ocean, ſunk, the waters which covered the Pyrennees and the whole of Europe would run with rapidity into theſe reſervoirs, and, of courſe, leave uncovered all the lands in this part of the world. The ſame revolution would extend to every other country. The waters appear to have never reached the ſummits of the higheſt mountains; beauſe they exhibit no relicks of marine productions, and no ſufficient marks of a long abode of the waters. However, as ſome of the matters of which they are compoſed, though all of the vitreſcent kind, ſeem to have derived their ſolidity and conſiſtence from the intervention and cement of water, and as they appear to have been formed, as already remarked, in the maſſes of ſand, or glaſs duſt, which formerly lay on the peaks of mountains, but which, in the progreſs of time, have been carried down to their bottoms by the rains, we cannot pronounce poſitively, that the waters of the ſea never ſtood higher than the places where ſhells are now found: The waters have perhaps ſtood much higher, even before their temperature permitted the exiſtence of ſhells. The greateſt height reached by the univerſal ocean is to us unknown. But we know that the waters were elevated from 1500 or 2000 fathoms above their preſent level; ſince ſhells are found in the Pyrennees at 1500 hundred fathoms, and in the Cordelieres at 2000.

If all the peaks of mountains were formed of ſolid glaſs, or of other matters immediately produced by fire, it would be unneceſſary to have recourſe to the abode of the waters, or to any other cauſe, in order to conceive how they aſſumed their conſiſtence. But moſt peaks of mountains ſeem to be compoſed of matters, which, though vitrifiable, have acquired their ſolidity by the intervention of water. We cannot, therefore, determine whether their conſiſtence is ſolely owing to the primitive fire, or whether the intervention and cement of water were not requiſite to complete the operation of fire, and to beſtow on theſe vitrifiable maſſes the qualities which they poſſeſs. Beſides, this ſuppoſition prevents not the primitive fire, which at firſt produced the greateſt inequalities on the globe, from being the chief cauſe of thoſe chains of mountains that traverſe its ſurface, and particularly of their cores or nuclei; but the contours of theſe ſame mountains have perhaps been diſpoſed and faſhioned by the waters at a ſubſequent period; for it is upon theſe contours, and at certain heights, that ſhells and other productions of the ſea are found.

To acquire a clear notion of the ancient caverns formed by the primitive fire, we muſt ſuppoſe the globe to be deprived of all its waters, and of all the matters which cover its ſurface, to the depth of ten or twelve hundred feet. By removing in idea this external bed of earth and water, the globe will preſent to us the form it poſſeſſed about the time of its firſt conſolidation. The whole maſs was compoſed of vitreous rock, or, if you will, of melted glaſs; and this matter, in cooling and acquiring conſiſtence, produced, like all other melted bodies, eminences, depreſſions, and cavities, upon the whole ſurface of the globe. Theſe internal cavities formed by fire, are the primitive caverns, and they are more numerous in the ſouthern than in the northern regions; becauſe the rotatory motion, which elevated the equatorial regions before conſolidation, likewiſe produced the greateſt derangement of the matter, and, by retarding the conſolidation, would concur with the action of the fire in giving riſe to a greater number of inequalities in this than in any other part of the globe. The waters coming from the Poles could not approach thoſe burning regions before they cooled. The vaults which ſupported theſe regions having ſucceſſively fallen in, the ſurface ſunk and broke in a thouſand places. For this reaſon, the greateſt inequalities of the globe are found in the equatorial regions: There the primitive caverns are more numerous than in any other part of the earth. They are likewiſe more profound, *i. e.* perhaps five or ſix leagues deep; becauſe the matter of the globe, while in a liquid ſtate, was agitated to that depth by the motion of rotation. But all the caverns in high mountains derive not their origin from the operation of primitive fire. Thoſe alone which are deeply ſituated below the mountains can be aſcribed to this cauſe. The more exterior and more elevated have been formed, as already remarked, by the operation of ſecondary cauſes. Hence the globe, deprived of its waters and the matters tranſported by them, would preſent to us a ſurface much more irregular than it appears with the aid of this covering. The great chains of mountains and their peaks and ridges, have not now the appearance of half of their real height. The whole are attached by their baſes to a vitrifiable rock, and are of the ſame nature. Thus we ſhould reckon three ſpecies of caverns produced by Nature: The firſt by the force of the primitive fire; the ſecond by the action of water; and the third by that of ſubterraneous fires: Each of theſe caverns, though different in their origin, may be diſtinguiſhed by examining the matters they contain, or by which they are ſurrounded.

ADDITIONS to the Article, Of the effect of Rains, Marſhes, Subterraneous Wood and Water, Vol. I. p. 473.

I.

Of the ſinking and derangement of certain Lands.

THE rupture of caverns, and the action of ſubterraneous fires, are the chief cauſes of the great revolutions which happen in the earth; but they are often produced by ſmaller cauſes. The filtration of the water, by diluting the clay, upon which almoſt all calcarious mountains reſt, has frequently made thoſe mountains incline and tumble down. Of theſe remarkable events I ſhall ſubjoin ſome examples.

'In the year 1757,' ſays M. Perronet, 'a part 'of the ground ſituated about half-way before 'we arrive at the Caſtle of Croix-fontaine, o'pened in many places, and ſucceſſively tum'bled down. The terrace wall, which incloſed 'this ground, was overturned, and the road, 'which was formerly at the foot of the wall, 'was obliged to be carried to a conſiderable di'ſtance.

'ſtance. . . . . This ground reſted upon a baſe 'of inclined earth.' This learned and chief engineer of our highways and bridges mentions another accident of the ſame kind which happened, in the year 1733, at Pardines, near Iſſoire in Auvergne. The ground, for about 400 fathoms in length by 300 in breadth, deſcended upon a pretty diſtant meadow, with all its houſes, trees, and herbage. He adds, that conſiderable portions of ground are ſometimes tranſported either by the rupture of reſervoirs of water, or by the ſudden melting of ſnows. In 1757, at the village of Guet, about ten leagues from Grenoble, on the road to Briançon, the whole ground, which lies on a declivity, ſlipt and deſcended in an inſtant towards Drac, which is about a mile diſtant. The earth ſplit in the village, and the part which moved off was ſix, eight, and nine feet lower than its former ſtation. This ground was ſituated on a pretty ſolid rock, which was inclined to the horizon about forty degrees *.

To theſe examples I ſhall add another fact, of which I have been a conſtant witneſs, and which has coſt me a conſiderable expence. The detached riſing ground, upon which the town and old caſtle of Montbard are ſituated, is elevated 140 feet above the level of the river, and its moſt rapid deſcent is to the north-eaſt. This

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* Hiſt. de l'Acad. des Sciences, année 1769, p. 233.

riſing ground is crowned with calcarious rocks, the ſtrata of which, when taken together, are 54 feet thick. They every where reſt upon a maſs of clay, which, of courſe, before reaching the level of the river, is 86 feet thick. My garden, which is ſurrounded with ſeveral terraces, is ſituated on the top of this riſing ground. From twenty-five to twenty-ſix fathoms of the laſt terrace-wall on the north-eaſt ſide, where the declivity is greateſt, gave way all at once, carrying along the inferior ground which would have gradually deſcended to the level of the ground near the river, if its progreſſive motion had not been prevented by taking down the whole wall. This wall was ſeven feet thick and founded on clay. The movement of the earth was very ſlow: I perceived that it was evidently occaſioned by the inſinuation of water. All the water which falls upon the platform on the top of this riſing ground, penetrates through the fiſſures of the rocks, and reaches the clay upon which they reſt: Of this fact we are aſcertained by two wells dug from the top of the rock to the clay. All the rain-water, therefore, which falls upon this platform and the adjacent terraces, collect upon the clay where the perpendicular fiſſures of the rock terminate. The water gives riſe to ſmall rills in different places, which are rendered ſtill more apparent by ſeveral wells dug below the rocks. Wherever this maſs of clay is cut by ditches, we ſee the water filtrating from above. It is not, therefore, ſurpriſing that walls, however ſolid, ſhould ſlip upon this firſt bed of moiſt clay, if they are not founded much lower, as I have done in rebuilding them. The ſame thing, however, has happened on the north-weſt ſide, where the declivity is gentler, and no rills of water appear. The clay had been removed at the diſtance of twelve or fifteen feet from a great wall of eleven feet thick, thirty-five feet high, and twelve fathoms long. This wall is conſtructed of good materials, and has ſubſiſted more than nine hundred years. The cut from which the clay was removed, though not above four or five feet deep, has produced a movement in this immenſe wall. It declines from the perpendicular about fifteen inches, and I could only prevent its downfall by abuttments of ſeven or eight feet thick, and founded at the depth of fourteen feet.

From theſe facts I drew the following concluſion, which is not ſo intereſting at preſent as it would have been in ages that are paſt, that there is not a caſtle or fortreſs ſituated upon heights, which might not be eaſily tumbled into the plain by a ſimple cut of ten or twelve feet deep and ſome fathoms wide. This cut ſhould be made at a ſmall diſtance from the laſt wall, and upon that ſide where the declivity is greateſt. This method, of which the ancients never dreamed, would have ſaved them the operation of battering-rams and other engines of war; and, even at preſent, might be employed, in many caſes, with advantage. I am convinced by my eyes, that, when theſe walls ſlipt, if the cut made for rebuilding them had not been ſpeedily filled with ſtrong maſon-work, the ancient walls, and the two towers that have ſubſiſted in good condition nine hundred years, and one of which is 125 feet high, would have tumbled into the valley, along with the rocks upon which they are founded. As moſt of our hills compoſed of calcarious ſtones reſt upon a clay baſe, the firſt ſtrata of which are always more or leſs moiſtened with the waters that filtrate through the crevices of the rocks, it appears to be certain, that, by expoſing theſe moiſtened beds to the air by a cut, the whole maſs of rocks and earth reſting upon the clay would ſlip, and in a few days tumble into the cut, eſpecially during wet weather. This mode of diſmantling a fortreſs is more ſimple than any hitherto invented; and experience has convinced me that its ſucceſs is certain.

II.

Of Turf.

TO what I have formerly remarked concerning turf, I ſhall ſubjoin the following facts:

In the juriſdiction of Bergues-Saint-Winock, Furnes, and Bourbourg, we find turf at three or four feet below the ſurface. Theſe beds of turf are generally two feet thick, and are compoſed of corrupted wood, of entire trees with their branches and leaves, and particularly of filberds which are known by their nuts, and the whole is interlaced with reeds and the roots of plants.

What is the origin of theſe beds of turf, which extend from Bruges through the whole flat country of Flanders as far as the river Aa, between the downs and the high country in the environs of Bergues? &c. In remote ages, when Flanders was only a vaſt foreſt, a ſudden inundation of the ſea muſt have deluged the whole country, and, in retiring, depoſited all the trees, wood, and twigs, which it had eradicated and deſtroyed in this loweſt territory of Flanders; and this event muſt have happened in the month of Auguſt or September; becauſe we ſtill find the leaves of trees, as well as nuts on the filberds. This inundation muſt have taken place long before that province was conquered by Julius Caeſar, ſince no mention is made of it in the writings of the ancients *.

In the bowels of the earth, we ſometimes find vegetables in a different ſtate from that of common turf. For example, in Mount Ganelon, near Compeigne, we find, on one ſide of the mountain, quarries of fine ſtones and the foſſil oyſters formerly mentioned, and, on the other ſide, we meet with a bed of the leaves of all kinds of trees, and alſo reeds, the whole blended together and incloſed in mud. When theſe leaves are ſtirred, we perceive the ſame muſty odour which we feel on the margin of the ſea; and theſe leaves preſerve their odour during ſeveral years. Beſides, the leaves are not deſtroyed; for we can eaſily diſtinguiſh their ſpecies: They are only dry, and ſlightly united to each other by the mud †.

‘ We diſtinguiſh,’ M. Guettard remarks, ‘ two ſpecies of turf: The one is compoſed of ‘ marine, and the other of terreſtrial plants. We ‘ ſuppoſe the firſt to have been formed when ‘ the ſea covered all thoſe parts of the earth ‘ which are now inhabited. The ſecond is ſup‘ poſed to have been ſuperinduced upon the for‘ mer. According to this ſyſtem, it is imagined ‘ that

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* Mem. pour la ſubdelegation de Dunkerque, relativement à l’Hiſt. Nat. de ce canton.

† Lettre de M. Leſchevin à M. de Buffon; *Compeigne*, 8. *Aout.* 1772.

‘ that the currents carried the ſea-plants into the ‘ hollows formed by the mountains, which were ‘ elevated above the waters, and, after being ‘ toſſed about by the waves, were depoſited in ‘ the hollows.

‘ This origin of turf is not impoſſible: The ‘ great quantity of ſea-plants is ſufficient to account for the phaenomenon. The Dutch even alledge, that the goodneſs of their turf is ‘ owing to the bitumen with which the ſea-‘ water is impregnated, and that they were formed by ſea-weeds. . . . .

‘ The turf-pits of Villeroy are ſituated in the ‘ valley through which the river Eſſone runs; ‘ and part of this valley extends from Roiſſy to ‘ Eſcharcon. . . . . It is even near Roiſſy that ‘ turfs were firſt dug. . . . . But thoſe near ‘ Eſcharcon are the beſt. . . . .

‘ The meadows where turf is dug are open ‘ and bad: They are filled with ruſhes, horſe-‘ tail, and other plants which grow in bad ſoils. ‘ Theſe meadows are dug to the depth of eight ‘ or ten feet. . . . . Next to the upper ſtratum, ‘ there is a bed of turf about a foot thick, and ‘ impregnated with river and land-ſhells. . . .

‘ This bed of turf filled with ſhells is commonly earthy: Thoſe which ſucceed are nearly of the ſame thickneſs, and are always better ‘ as we deſcend. Theſe turfs are of a blackiſh ‘ brown colour, intermixed with reeds, ruſhes, 'and other plants. We ſee no ſhells in theſe 'beds. . . . .

'In maſſes of turf we ſometimes find the 'ſtems of willow and poplars, and ſometimes 'the roots of theſe and ſimilar trees. On the 'Eſcharcon ſide, an oak was diſcovered at the 'depth of nine feet. It was black and almoſt 'corrupted. It crumbled into duſt, after being 'expoſed to the air. Another was found, on the 'Roiſſy ſide, between the ſoil and the turf, at 'the depth of two feet. Near Eſcharcon, the 'horns of a ſtag were found three or four feet 'below the ſurface. . . .

'Turfs are perhaps equally abundant in the 'environs of Etampes, as near Villeroy. Theſe 'turfs contain but very little moſs. Their co'lour is a fine black. They are heavy, and 'burn well in an ordinary fire. Good charcoal 'might be made of them. . . .

'The turfs in the neighbourhood of Etampes 'may be conſidered as a continuation of thoſe 'of Villeroy. In a word, all the meadows ad'jacent to the river of Etampes are probably 'full of turf. The ſame remark is applicable to 'the meadows through which the river Eſſone 'runs: Theſe meadows produce the ſame plants 'as thoſe of Etampes and Villeroy *.'

According to this author, there are in France a number of places from which turf may be obtained,

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* Mem. de l'Acad. des Sciences, année 1761, p. 380.—397.

tained, as at Bourneuille, at Croué, near Beauvais, at Bruneval, in the environs of Péronne, in the dioceſe of Troyes in Champagne, &c. This combuſtible ſubſtance would be a great reſource, if it were uſed in ſuch places as want wood.

There are likewiſe turfs near Vitry-le-francois, and in the moraſs along the Marne. Theſe turfs are good, and contain great quantities of acorn ſhells. The marſh of Saint-Gon in the environs of Châlons is full of turf, which the inhabitants will ſoon be obliged to uſe for want of wood *.

III.

Of Subterraneous, Petrified, and Charred Wood.

' IN the territories of the Duke of Sax-Co-' bourg, which lie on the frontiers of Franco-' nia and Saxe, and at ſome leagues from the ' town of Cobourg, there were found, at a ſmall ' depth, whole trees ſo completely petrified, that ' they were as beautiful and hard as agates. ' Some ſpecimens of them were given by the ' Princes of Saxe to M. Schoepflin, who tranſmit-

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* Note communicated to M. de Buffon, by M. Greignon, Aug. 6. 1777.

'ted two of them to M. de Buffon for the royal 'cabinet. Vaſes and other beautiful utenſils 'have been made of this petrified wood *.'

Wood in its natural ſtate has likewiſe been found at great depths. M. du Verny, an officer of artillery, ſent me ſome ſpecimens of it, accompanied with the following letter: 'The town of Fère, in the garriſon of which I 'am ſtationed, on the 15th of Auguſt 1753, or'dered a ſearch to be made for water by means 'of boring: At 39 feet below the ſurface, they 'found a bed of marl, which they continued to 'pierce for 121 feet: Hence, at the depth of '160 feet, they found, at two different trials, 'the augre filled with marl, intermixed with 'numerous fragments of wood, which every 'perſon eaſily recogniſed to be oak. I ſend 'you two ſpecimens of this wood. During the 'ſucceeding days operations, they continued to 'find the ſame marl, but not ſo much mixed 'with wood, as far as the depth of 210 feet, 'where they ceaſed to bore †.'

'In the territory of Cobourg, which is a 'branch of the houſe of Saxe, we find,' M. Juſti remarks, 'petrified wood of a prodigious 'ſize. In the mountains of Miſnia, entire trees 'have been dug out of the earth, which were 'converted into very fine agate. The Imperial cabinet

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* Lettre de M. Schoepflin, *Straſbourg, Sept.* 24. 1746.

† Lettre de M. Breſſe du Verny; *La Fère, Nov.* 14. 1753.

‘ cabinet of Vienna contains many petrifications ‘ of this kind. A great log of this wood was ‘ ſent to the ſame cabinet : The part which had ‘ been wood was changed into a beautiful agate ‘ of a grayiſh black colour ; and, inſtead of bark, ‘ the trunk was ſurrounded with a belt of fine ‘ white agate. . . . . .

‘ The preſent Emperor wiſhed that a method ‘ of aſcertaining the age of petrifactions might ‘ be diſcovered. . . . . . He ordered his ‘ ambaſſador at Conſtantinople to aſk permiſſion to take up from the Danube one of the ‘ piles of Trajan’s bridge, which is ſome miles ‘ below Belgrade. This permiſſion being granted, one of the piles was drawn up, which it ‘ was imagined would have been petrified by ‘ the water. But, after ſuch a lapſe of time, it ‘ was diſcovered that the proceſs of petrifaction ‘ had made very little progreſs. Though this ‘ pile had remained in the Danube above 1600 ‘ years, the petrifaction had not proceeded above ‘ three quarters of an inch, and even leſs. The ‘ reſt of the wood was very little altered, and ‘ had only begun to be calcined.

‘ If a juſt concluſion, with regard to all other ‘ petrifactions, could be drawn from this ſingle ‘ fact, Nature would perhaps require fifty thouſand years to change trees, of the ſize of thoſe ‘ found petrified in certain places, into ſtones. ‘ But, in particular ſituations, many cauſes may ‘ concur in haſtening the proceſs of petrifaction. . . . .

'At Vienna there is to be ſeen a petrified 'log, which was brought from the Carpathian 'mountains in Hungary. Upon this log the 'marks of the hatchet, which had been made 'before its petrifaction, are diſtinctly viſible; 'and theſe marks are ſo little altered by the 'change the wood has undergone, that we per'ceive they have been made by a ſmall inſtru'ment. . . . .

'Beſides, it appears that petrified wood is not 'ſo rare as is commonly imagined; and that, 'to diſcover it in many places, requires only 'the nice eye of a naturaliſt. Near Mansfeld, 'I ſaw a great quantity of petrified oak in a 'place where many people daily paſs, without 'perceiving this phaenomenon. Some logs were 'entirely petrified, and in theſe we diſtinctly 'perceived the rings formed by the annual 'growth, the bark, the place where they were 'cut, and all the characters of oak-wood *.'

M. Clozier, who found different pieces of petrified wood upon the hills in the neighbourhood of Etampes, and particularly on that of Saint-Symphorien, imagined that theſe fragments might have proceeded from ſome petrified trunks in the mountains. He, therefore, cauſed pits to be dug in a part of the mountain of Saint-Symphorien that had been pointed out to him. After digging ſeveral feet deep, he firſt diſcovered

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* Journal étranger, *mois d'Octobre* 1756, *p.* 160.

diſcovered a petrified root, which led him to the trunk of a tree of the ſame ſpecies.

This root, from its extremity to its junction with the trunk, was, ſays M. Clozier, five feet in length; there were other five roots, but not equally long. . . . .

The middling and ſmall roots were not petrified, or at leaſt their petrification was ſo brittle, that they remained in the ſand, where the trunk was in the form of powder or aſhes. It is reaſonable to think, that, when the proceſs of petrifaction was communicated to theſe roots, they had been almoſt corrupted, and that the ligneous parts of which they were compoſed, being too much ſeparated by petrifaction, could not acquire the degree of ſolidity neceſſary to a genuine petrifaction. . . .

The thickeſt part of the trunk was near ſix feet in circumference. Its length was three feet ten inches, and its weight was from five to ſix hundred pounds. The trunk, as well as the roots, had all the appearance of wood, as the bark, the inner rhind, the ſolid and corrupted wood, the holes of large and ſmall worms, and even the excrements of theſe worms. All theſe parts were petrified, but were not ſo ſolid and hard as the ligneous body, which had been perfectly ſound when the proceſs of petrifaction commenced. The ligneous body is converted into a real flint of various colours, which ſtrikes fire with ſteel, and produces, after being ſtruck or rubbed, a very ſtrong ſmell of ſulphur. . . .

This petrified trunk was bedded in a horizontal direction. . . . It was covered with more than four feet of earth, and its root was not above two feet below the ſurface *.

M. l'Abbé Mazéas, who diſcovered, at half a mile from Rome, a quarry of petrified wood, expreſſes himſelf in the following terms:

‘ This quarry of petrified wood forms a ſucceſſion of hillocks in the front of Monte-Mario, on the other ſide of the Tiber. . . . Of theſe fragments of wood, irregularly heaped upon each other, ſome have the appearance of a hard dry earth, which ſeems not to be fit for the nouriſhment of vegetables: Others are petrified, and have the colour, the brilliancy, and the hardneſs of the reſin known in the ſhops by the appellation of *colophanus* This petrified wood is found in a ſoil ſimilar to the former, but more moiſt. Both are perfectly well preſerved. The whole are reduced, by calcination, into a true earth; and none of them produce allum, either by the application of fire, or by combining them with the vitriolic acid †.’

M. du Monchau, a phyſician and expert naturaliſt, has ſent me, for the royal cabinet, a

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[*] Mem. des Savans étrangers, tom. 2. p. 598.—604.

[†] Mem. des Savans étrangers, tom. 5. p. 388.

piece of petrified wood with the following hiſtorical account:

'The piece of petrified wood, which I have 'the honour of tranſmitting to you, was found 'at the depth of more than 150 feet below the 'ſurface. . . . Laſt year (1754) when digging 'a pit in queſt of coal, at Notre-Dame-au-bois, 'a village ſituated between Condé, Saint-Amand, 'Mortagne, and Valenciennes, we found, a'bout 600 fathoms from Eſcaut, and after paſ'ſing three water-levels, firſt ſeven feet of 'rock or hard ſtone called *tourtia* in the lan'guage of colliers; afterwards, when we ar'rived at a marſhy earth, we found, at the depth 'of 150 feet, as already remarked, the trunk of a 'tree of two feet in diameter, which lay acroſs 'the pit, and, of courſe, we were prevented 'from meaſuring its length, It reſted upon a 'large free-ſtone; and many pieces were cut 'off from this trunk by the curious. The ſmall 'fragment I have the honour of ſending you 'was cut off from a ſpecimen given to M. Lau'rent, a learned mechanic. . . .

'This wood ſeemed rather to have been convert'ed into coal than petrified. How could a tree be 'ſunk ſo deep into the earth? Has the ſoil in 'which the tree was found been formerly as low? 'If that is the caſe, how could this ſoil be aug'mented 150 feet? From whence did all this 'earth proceed?

‘ The ſeven feet of *tourtia* obſerved by M. ‘ Laurent, which exiſts alſo in all the coal-mines ‘ for ten leagues round, have, according to the ‘ above ſuppoſition, been produced poſterior to ‘ this accumulation of earth.

‘ I leave this matter, Sir, to your deciſion: ‘ You are ſo intimately acquainted with Nature, ‘ that none of her myſteries can be long concealed from you; and I have no doubt that you ‘ will be able to explain this wonderful phaenomenon *.’

M. Fougeroux de Bondaroy, of the Royal Academy of Sciences, relates ſeveral facts concerning petrified wood, which merit attention.

‘ All the fibrous ſtones,’ he remarks, ‘ which ‘ have ſome reſemblance to wood, are not petrified wood. But there are many others which ‘ muſt be recogniſed as ſuch, eſpecially if we attend to the peculiar organization of vegetables. . . .

‘ Facts are not wanting to prove that wood ‘ may be converted into ſtone, with as much ‘ eaſe at leaſt as ſeveral other ſubſtances which ‘ inconteſtibly undergo this tranſmutation. But ‘ it is difficult to explain how this effect is produced. I hope I may be permitted to hazard ‘ ſome conjectures on the ſubject, which I ſhall

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* Lettre de M. Dumonchau à M. de Buffon; *Douai, Jan.* 29. 1755.

‘ endeavour to ſupport by facts and obſervations.

‘ We find wood which may be conſidered as only half petrified, and not much heavier than common wood. Specimens of this kind are eaſily divided into plates, or even into filaments, like certain corrupted timber. Others are more petrified, and have the weight, the hardneſs, and the opacity of free-ſtone. Others, whoſe petrifaction is ſtill more perfect, admit the ſame poliſh as marble; while others acquire that of fine oriental agates. I have an excellent ſpecimen ſent from Martinico to M. du Hamel, which is converted into a moſt beautiful ſardonix. Laſtly, we find wood changed into ſlate. Among theſe ſpecimens, there are ſome which have retained the organization of wood ſo completely, that we diſcover with a lens every appearance exhibited in unpetrified wood.

‘ We have ſeen ſome ſpecimens encruſted with a ſandy iron ore, and others penetrated with a ſubſtance which, being compoſed of ſulphur and vitriol, makes them approach the ſtate of pyrites. Some of them are, if we may uſe the expreſſion, larded with a very pure iron ore; and others are traverſed by veins of very black agate.

‘ We find pieces of wood, one part of which is converted into a ſtone, and the other into 'agate: The part converted into ſtone is tender; but the other has the hardneſs peculiar 'to precious ſtones.

'But, how ſhould certain pieces, though converted into hard agate, preſerve the diſtinct 'characters of organization, as the concentric 'circles, the inſertions, the extremities of the 'tubes deſtined to tranſmit the ſap, the bark, 'the inner rhind, and the wood? If the vegetable ſubſtance were entirely deſtroyed, we 'ſhould only ſee an agate, without any of the 'organic characters formerly mentioned. To 'preſerve this appearance of organization, if we 'ſuppoſe that the wood ſubſiſts, and that the 'pores alone are filled with the petrifying juice, 'it ſhould appear, that the vegetable parts might 'be extracted from the agate. But I could never make any progreſs in this operation: I, 'therefore, think, that the ſpecimens in queſtion 'retain no parts which have preſerved the nature of wood. To give perſpicuity to my idea, I beg the reader to recollect, that, when 'a piece of wood is diſtilled in a retort, the coal 'which remains after diſtillation is not a ſixth 'part of the original weight of the wood. 'When this coal is burnt, we obtain only a 'ſmall quantity of aſhes, which will ſtill diminiſh after the lixivial ſalts are abſtracted.

'This ſmall quantity of aſhes being the only 'fixed part, the chemical analyſis proves, that 'the fixed parts of a piece of wood are really 'very trifling, and that the greateſt portion of 'vegetable matter is deſtructible, and may be 'gradually carried off, as the wood corrupts.

'Now, if we conſider that the greater part of 'the wood is deſtroyed, and that what remains 'is a light earth, and eaſily permeable by the 'petrifying juice, its converſion into ſtone, agate, or ſardonix, will not be more difficult to 'conceive than that of bole, clay, or any other 'earth. The only difference is, that the vegetable earth preſerves the appearance of organization, and the petrifying juice inſinuates into 'its pores, without deſtroying its original characters *.'

Some facts and obſervations remain ſtill to be added. In Auguſt 1773, at Montigni-ſur-Braine, in the diſtrict of Challon and juriſdiction of Auxonne, when digging a copper mine, the workmen, at the depth of 33 feet, found a tree lying on its ſide; but the ſpecies of it could not be diſcovered. The ſuperior ſtrata ſeemed to have never been touched by the hand of man; for, below the ſoil, there was a bed of 8 feet of clay; then 10 feet of ſand; then a bed of fullers earth about 6 or 7 feet; then another bed of the ſame mixed with ſtones; and, laſtly, a bed of black ſand of 3 feet. The tree was found

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* Mem. de l'Acad. des Sciences, année 1759, p. 431.—452.

found in the fullers earth. The river Braine is to the eaſt, and not above a gun-ſhot from this place. It runs in a meadow 80 feet lower than the ſite of the copper*.

M. de Grignon informed me; that, on the borders of the Marne, near St Dizier, there is a bed of pyritous wood, the organization of which is apparent. This bed is ſituated under a ſtratum of free-ſtone, which is covered with a ſtratum of pyrites, and above the pyrites is a ſtratum of lime-ſtone. The bed of pyritous wood lies upon a blackiſh clay.

He likewiſe found, in the pits dug for diſcovering the ſubterraneous town of Châtelet, inſtruments of iron with wooden handles. He remarked that this wood was converted into a genuine iron-ore of the hematites ſpecies. The organization of the wood was not deſtroyed; but it was brittle, and its whole texture was as cloſe as that of the hematites. Theſe iron inſtruments with wooden handles had been buried in the earth ſixteen or ſeventeen hundred years. The converſion of the wood into hematites had been affected by the decompoſition of the iron, which had gradually filled all the pores of the wood.

IV.

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* Lettre de Mad. la Comteſſe de Clermont-Montoiſon à M. de Buffon.

IV.

Of Bones ſometimes found in the interior parts of the Earth.

‘ IN the pariſh of Haux, which is ſituated ‘ between two ſeas, and about half a league ‘ from the port of Langoiran, a point of a rock, ‘ of 11 feet high, detached itſelf from the coaſt, ‘ which was formerly 30 feet high. By its fall ‘ it ſpread over the valley a great quantity of animal bones or fragments of bones, ſome of ‘ which were petrified. That they are bones is ‘ unqueſtionable; but it is difficult to aſcertain the ‘ animals to which they belong. The greateſt ‘ number conſiſts of teeth; ſome of them perhaps ‘ belong to the ox or horſe; but, without marking ‘ the difference in figure, moſt of them are larger ‘ than the teeth of theſe animals. There are ‘ likewiſe thigh or leg-bones, and a fragment ‘ of a ſtag or elk’s horn. The whole are covered with common earth, and ſituated between ‘ two ſtrata of rock. We muſt ſuppoſe that the ‘ carcaſſes of animals have been thrown into a ‘ hollow rock, and, after the fleſh had corrupted, a rock of 11 feet high had been formed ‘ above them, which would require the operation of many ages. . . .

‘ The Gentlemen of the Academy of Bourdeaux, who examined theſe bones with phi-

‘ loſophical accuracy, diſcovered, that, when a ‘ number of fragments were put on a very ‘ briſk fire, they were converted into a fine Tur‘ quois blue; and that ſome portions became ſo ‘ hard, that, when cut by a lapidary, they re‘ ceived a fine poliſh. . . . It muſt alſo be re‘ marked, that bones which evidently belonged ‘ to different animals were equally converted in‘ to Turquois *.’

‘ On the 28th of January 1760,’ ſays M. de Guettard, ‘ there were found, 160 fathoms a‘ bove the mineral baths, bones included in a ‘ rock with a gray ſurface. This rock was nei‘ ther laminated nor conſiſted of ſeparate ſtrata, ‘ but was one continued maſs of ſtone. . . .

‘ After having, by means of gun-powder, pe‘ netrated five feet deep into this rock, we found ‘ a great number of human bones belonging to ‘ every part of the body, as jaw-bones with their ‘ teeth, bones of the arms, thighs, limbs, ribs, ‘ rotulae, &c. jumbled together in the greateſt ‘ diſorder. Entire ſkulls, or portions of them, ‘ chiefly prevailed.

‘ Beſide theſe human bones, we met with ‘ ſeveral fragments which could not be aſcribed ‘ to man. In ſome places, they are in conti‘ nued maſſes, and in others more diſperſed. . .

‘ When we arrived at the depth of four feet ‘ and a half, we found ſix human heads in an ‘ inclined

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* Hiſt. de l’Acad. des Sciences, année 1719, p. 24.

'inclined poſition. In five of theſe heads, the 'occiput with its appendages, except the bones 'of the face, were preſerved. This occiput was 'partly encruſted with ſtone, its cavity was fill- 'ed with ſtone, and had aſſumed the ſame mould 'or figure. In the ſixth head, the face is en- 'tire: It is broad in proportion to its length. 'We eaſily diſtinguiſh the form of the fleſhy 'cheeks. The eyes are ſhut, pretty long, but 'narrow. The front is large, and the noſe ve- 'ry flat, but well formed; the middle line is 'diſtinguiſhable. The mouth is well made, 'and ſhut; the upper lip is a little thick in pro- 'portion to the under. The chin is well pro- 'portioned, and the whole muſcles are ſtrongly 'marked. The colour of the head is reddiſh, 'and reſembles thoſe of the Tritons feigned by 'painters. Its ſubſtance is ſimilar to that of 'the ſtone in which it was found; it is, proper- 'ly ſpeaking, only the maſk of the natural 'head.'

The above relation was ſent by M. le Baron de Gaillard-Lonjumeau to Madame de Boiſjourdain, who tranſmitted it to M. Guettard, with ſome ſpecimens of the bones. That theſe bones were really human, is a very doubtful point; 'for every appearance in this quarry,' M. de Lonjumeau remarks, 'announces that it has 'been formed of relicks of bodies broken in 'pieces, and which had been long toſſed about

‘ by the waves of the ſea before they were col‘ lected into one heap. As this maſs of bones ‘ lies horizontally, and has been ſucceſſively co‘ vered with ſtony matter, it is eaſy to conceive ‘ how a maſk was formed on the faces of thoſe ‘ heads, the fleſh having little time to corrupt, e‘ ſpecially when the bodies were buried under the ‘ water. We may, therefore, reaſonably con‘ clude, that theſe heads were not human. . . . ‘ They rather ſeem to be the heads of thoſe fiſhes, ‘ whoſe teeth are found in the ſame parts of ‘ the ſtones along with the bones ſuppoſed to ‘ belong to the human ſpecies.

‘ It appears that the collection of bones in ‘ the environs of Aix, are ſimilar to thoſe diſco‘ vered ſome years ago by M. Borda near Dax ‘ in Gaſcony. The teeth diſcovered at Aix, by ‘ the deſcription given of them, ſeem to reſem‘ ble thoſe found at Dax, of which an under ‘ jaw is ſtill preſerved. This jaw unqueſtiona‘ bly belongs to a large fiſh. . . . I muſt, there‘ fore, conclude, that the bones in the quarry of ‘ Aix are ſimilar to thoſe diſcovered at Dax; . . ‘ and that theſe bones, whatever they are, ‘ ſhould be referred to the ſkeletons of fiſhes ‘ rather than to thoſe of man. . . .

‘ One of the heads in queſtion was about ſe‘ ven and a half inches long by three and ſome ‘ lines broad. Its figure is that of an oblong ‘ globe, flat at the baſe, thicker at the poſterior

‘ than the anterior end, and divided in the broad-‘ eſt part by ſeven or eight bands from ſeven ‘ to twelve lines wide. Each band is likewiſe ‘ divided into two equal parts by a ſlight fur-‘ row. The bands extend from the baſe to the ‘ ſummit. Thoſe of one ſide are ſeparated from ‘ thoſe of the other by another and deeper fur-‘ row, which gradually enlarges from the ante-‘ rior to the poſterior part.

‘ From this deſcription we cannot recognize ‘ the mould of a human head. The bones of ‘ man's head are not divided into bands. The ‘ human head is compoſed of four principal ‘ bones, the figures of which appear not in the ‘ mould above deſcribed. It has not an interior ‘ creſt which extends longitudinally from the ‘ anterior to the poſterior part, and divides it ‘ into two equal parts, which might give riſe to ‘ the furrow on the ſuperior part of the ſtony ‘ mould.

‘ Theſe conſiderations induce me to think, ‘ that this ſubſtance is rather the body of a nau-‘ tilus than a human head. There are nautili ‘ actually divided into bands or bucklers like this ‘ mould. They have a channel or furrow which ‘ runs along the whole curvature, and divides ‘ them into two, from which the ſtony furrow ‘ might derive its origin *,’ &c.

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* Mem. de l'Acad. des Sciences, année 1760, p. 209. —218.

I am perſuaded, as well as M. le Baron de Lonjumeau, that theſe heads never belonged to men, but to animals of the ſeal kind, to ſea-otters, and to ſea lions or bears. It is not at Aix or Dax alone, that the heads and bones of theſe animals are found in rocks and caverns. His Highneſs the preſent Prince Marcgrave of Anſpach, who to great affability unites a remarkable taſte for knowledge, has been ſo obliging as to give me, for the Royal Cabinet, a collection of bones from the caverns of Gaillenrente in his Marcgraviate of Bareith. M. Daubenton has compared theſe bones with thoſe of the common bear, from which they differ only by being larger. The head and teeth are longer and thicker; and the muzzle is longer and more protuberant than in our largeſt bears. In this collection, with which this noble Prince has enriched our cabinet, there is a head which naturaliſts have denominated *the head of M. de Buffon's ſmall ſeal*; but, as we know not the form and ſtructure of the heads of ſea lions, bears, and large and ſmall ſeals, we ſhall ſuſpend our judgment concerning the animals to which theſe foſſil bones have appertained.

ADDITIONS to the Article, Of the Changes of Sea into Land, Vol. I. p. 483.

IN traverſing the coaſts of France, we perceive that a part of Brittany, Picardy, Flanders, and Lower Normandy, have very recently been deſerted by the ſea; becauſe, through all this extent of country, we ſtill find great quantities of oyſters, and other ſhells, in their natural ſtate. We are certain, from experience, that, for a century paſt, the ſea has been retiring from the coaſt of Dunkirk. When the moles of this port were conſtructing in the year 1670, the fort of Good-hope, which terminate one of theſe moles, was built upon piles a great way beyond the low water-mark. But, at preſent, the water never advances nearer this fort than 300 fathoms. In 1714, when the new harbour of Mardik was deepening, the moles were likewiſe carried beyond the low water-mark; but now, when the tide is ebb, there is a dry ſpace of more than 500 fathoms. If the ſea continues thus gradually to retire, Dunkirk, like Aiguemortes, will, in a few centuries, be no longer a ſea-port. If the ſea has loſt ground ſo conſiderably in our times, how far muſt it have retired ſince the beginning of the world * ?

The bare inſpection of Saintonge is ſufficient to convince us, that it was formerly covered by the ſea. The ocean having abandoned theſe lands, the Charente followed as the waters retired, and formed a river where formerly there was only a great lake or moraſs. The country of Aunis, which was anciently covered by the ſea and ſtagnant waters, is one of the moſt recent lands of France. It is even probable that this territory was a moraſs about the end of the fourteenth century †.

It appears, therefore, that the ocean, during ſome centuries, has retired many feet from all our coaſts; and if we examine thoſe of the Mediterranean, from Rouſſillon to Provence, we ſhall find that this ſea has likewiſe retreated nearly in the ſame proportion. Theſe facts render it evident, that the circumference of all the coaſts of Spain and Portugal, as well as thoſe of France, is greatly extended. The ſame obſervation has been made with regard to Sweden, where ſome philoſophers have conjectured, that, in the courſe of 4000 years, the Baltic, the depth of which exceeds not thirty fathoms, will be totally abandoned by the waters.

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* Mem. pour la ſubdelegation de Dunkerque, relativement à la Hiſt. nat. de ce canton.

† Extrait de l'hiſt. de la Rochelle, art. 2. et 3:

If ſimilar obſervations were made in every country, I am perſuaded, that, in general, the ſea would be found to have retired from every coaſt. The ſame cauſes which produced its firſt retreat and ſucceſſive ſinking, are not abſolutely annihilated. In the beginning, the ſea was two thouſand fathoms above its preſent level. The immenſe ſwellings on the ſurface of the globe, which firſt ſubſided, made the waters ſink, at firſt rapidly, and afterwards in proportion as the more inconſiderable caverns gave way. The ſea, of courſe, was proportionally depreſſed; and, as many caverns ſtill exiſt, which muſt, from time to time, ſink, either by the action of volcano's, by the force of water, or by earthquakes, we may with certainty predict, that the ocean will continue to retire, and, conſequently, that the extent of all our continents will be gradually augmented.

FACTS AND ARGUMENTS

IN SUPPORT OF THE

COUNT DE BUFFON's

EPOCHS OF NATURE.

THE treatiſe compoſed by the Count de Buffon, under the title of *Les Epoques de la Nature*, is exceedingly ingenious. It is intended to eſtabliſh by facts and reaſoning, his theory of the formation of the Planets *. But as this theory, however it may be reliſhed on the Continent, is perhaps too fanciful to receive the general approbation of the cool and deliberate Briton, the tranſlator has been adviſed not to render it into Engliſh. Many of the facts, however, are too important to be omitted. Inſtead of a regular tranſlation, therefore, he ſhall give a generall view only of the poſitions laid down in this treatiſe, together with the moſt intereſting facts produced in ſupport of theſe poſitions.

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* See vol. I. p. 59. of this work.

The Count de Buffon begins his ſubject with a preliminary diſcourſe, in which he endeavours to unfold the different changes the terreſtrial globe has undergone from is firſt projection out of the ſun to the preſent time. In this diſcourſe the author obſerves the following order: 1. He mentions ſuch facts as may lead us to the origin of Nature. 2. He marks thoſe monuments which ought to be regarded as the evidences of the firſt ages. 3. He collects ſuch traditions as may convey ſome idea of the ages which ſucceeded. After which, ſays he, we ſhall endeavour to connect the whole by analogies, and to form a chain which, from the commencement of time, ſhall deſcend to the preſent days.

FIRST FACT.

The earth is elevated at the Equator and depreſſed at the poles, in the proportion required by the laws of gravity and of the centrifugal force.

SECOND FACT.

The earth poſſeſſes an internal heat which is proper to itſelf, and independent of that communicated to it by the rays of the ſun.

THIRD FACT.

The heat conveyed to the earth by the ſun is very ſmall when compared with the heat proper to the globe; and this heat tranſmitted by the ſun would not alone be ſufficient to ſupport animated nature.

FOURTH FACT.

The materials of which the earth is compoſed are, in general, of a vitreous nature, and the whole of them may be converted into glaſs.

FIFTH FACT.

We find on the whole ſurface of the earth, and even on the mountains, to the height of 1500 and 2000 fathoms, an immenſe quantity of ſhells and other relicks of marine productions.

The firſt fact; namely, the elevation of the globe at the Equator and its depreſſion at the poles, has been mathematically demonſtrated and phyſically proved by the theory of gravitation, and by experiments with the pendulum. The figure of the earth is preciſely the ſame which a fluid globe revolving round its axis with equal celerity would aſſume. Hence the matter of which the earth is compoſed was in a ſtate of fluidity the moment it aſſumed its form, and this moment happened whenever it began to turn round its own axis. Now, though heat is the general cauſe of fluidity, ſince water itſelf, without heat, would form a ſolid maſs, we have two methods of conceiving the poſſibility of the primitive fluid ſtate of the earth. The firſt is the ſolution of terreſtrial matters in water; and the ſecond is their liquefaction by fire. But moſt of the ſolid matters of which the earth is compoſed are not ſoluble in water; and, at the ſame time, the quantity of water, in proportion to that of dry and ſolid matter, is ſo ſmall, that it is impoſſible the one could be diſſolved by the other. Of courſe, as this ſtate of fluidity could not be effected by diſſolution or maceration in water, this fluidity muſt have been produced by the operation of fire.

This concluſion aſſumes a new degree of probability from the ſecond fact, and is rendered certain by the third. The internal heat of the globe, which ſtill ſubſiſts partially, and is greater than that afforded by the ſun, ſhews that this primitive fire is not yet nearly diſſipated. The ſurface of the earth is colder than its interior parts. Uncontrovertible and reiterated experiments evince, that the whole maſs of the globe has a heat proper to itſelf, and totally independent of that of the ſun. This heat is rendered evident by comparing our winters with our ſummers *; and it is ſtill more palpable when we penetrate into the bowels of the earth. At equal depths, it is invariably the ſame, and it appears to augment in proportion as we deſcend.

'At no great depth, we perceive a heat which 'never varies with the temperature of the 'atmoſphere. We know, that the liquor of the 'thermometer remains, during the whole year, 'at the ſame height in the caves of the Obſerva'tory, which exceed not 84 feet or 14 fathoms 'below the ſurface. Hence this point has 'been fixed as the mean temperature of our 'climate. This heat commonly continues 'nearly the ſame from 14 or 15 to 60, 80, or '100 fathoms, more or leſs, according to cir'cumſtances, as we experience in our mines. 'Beyond this depth it augments, and ſome'times

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* See *Suppl. tom.* 1. *part.* 1. and particularly the two Memoirs *ſur la temperature des planètes*, Suppl. tom. 2.

‘ times becomes ſo great, that the workmen ‘ could not ſupport it, if they were not cooled ‘ by freſh air, either from air-pits, or from falls ‘ of water. . . M. de Genſanne found, that, ‘ in the mines of Giromagny, three leagues ‘ from Béfort, when the thermometer was carried 52 fathoms deep, it ſtood at 10 degrees, ‘ as in the caves of the Obſervatory; that, at ‘ 106 fathoms, it ſtood at 10^{1} degrees; that, ‘ at 158 fathoms, it mounted to $15\frac{1}{2}$ degrees; ‘ and that, at 222 fathoms, it roſe to $18\frac{1}{6}$ degrees *.’

‘ In proportion as we deſcend into the bowels of the earth,’ M. de Genſanne remarks, ‘ we perceive a ſenſible increaſe of heat. 1800 ‘ feet below the level of the Rhine, at Huninguen in Alſace, I found, that the heat was ſo ‘ great as to produce a ſenſible evaporation from water. A detail of my experiments on ‘ this ſubject may be ſeen in the laſt edition of ‘ that excellent *Traité de la glace* compoſed ‘ by my deceaſed illuſtrious friend M. Dortous ‘ de Mairan †.’

‘ All the rich veins of every ſpecies of metal,’ ſays M. Eller, ‘ are in the perpendicular ‘ fiſſures of the earth; and the depth of theſe ‘ fiſſures cannot be aſcertained. In Germany, ‘ ſome of them have been traced above 6000 ‘ feet

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[*] Diſſert. ſur la glace, par M. Mairan, p. 60.

[†] Hiſt. Nat. de Languedoc, tom. 1. p. 24.

'feet deep. In proportion as the miners de'ſcend, they feel that the temperature of the 'air becomes always hotter *.'

Though our deepeſt mines and pits are inconſiderable excavations; yet the internal heat is more ſenſibly felt in them than on the ſurface. We may, therefore, preſume, that, if we could penetrate ſtill deeper, this heat would increaſe, and that the parts near the centre of the earth are hotter than thoſe more diſtant. This internal heat is likewiſe apparent from the temperature of the ocean, the waters of which, at equal depths, exhibit nearly the ſame heat as that of the interior parts of the earth. 'Having plunged a 'thermometer,' M. Marſigli remarks, 'into the 'ſea in different places and at different times, 'it was found that the temperature at 10, 20, '30, and 120 fathoms, was equally from 10 to '10$\frac{3}{4}$ degrees †'. On this ſubject M. de Mairan judiciouſly remarks, 'that the hotteſt wa'ters which are at the greateſt depth, muſt, as 'being the lighteſt, continually aſcend above 'thoſe that are heavier. Hence, according to 'Marſigli's obſervations, the temperature of this 'immenſe body of water muſt be always near'ly equal, except near the ſurface, which is 'expoſed

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* Mem. ſur la generation des metaux. Academie de Berlin, année 1733.

† L. Hiſt. phyſique de la mer par Marſigli, p. 16.

‘ expoſed to the impreſſions of the air, where ‘ the water ſometimes freezes before it has time ‘ to deſcend by its own weight and coolneſs *.’

Beſides, it is eaſy to ſhow, that the fluidity of the ocean ought not, in general, to be aſcribed to the powers of the ſolar rays; ſince we learn from experience, that the light of the ſun does not penetrate the moſt limpid water above ſix hundred feet; and, of courſe, that its heat will not reach above a fourth part of that depth, or one hundred and fifty feet. The late M. Bouguer, a learned aſtronomer of the Royal Academy of Sciences, found, that, when ſixteen pieces of common glaſs were applied to each other, and making a thickneſs of 9½ lines, the light, in paſſing through theſe ſixteen pieces of glaſs, was diminiſhed 247 times. He then placed ſeventy-four pieces of the ſame glaſs, in a tube, and at ſome diſtance from each other. When this experiment was made, the ſun was 50 degrees above the horizon. A very faint appearance of the ſun's diſk was ſtill perceptible through theſe 74 pieces of glaſs. The perſons who attended him could likewiſe perceive, but with difficulty, a feeble light. But, when other three pieces of glaſs were added to the ſeventy-four none of them could diſtinguiſh the ſmalleſt veſtige of light. Hence, if

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* Diſſert. ſur la glace, p. 69.

if we ſuppoſe eighty pieces of the ſame glaſs, we have a thickneſs which will render it perfectly opaque.

From this analogy between the tranſparency of glaſs and water, M. Bouguer found, that, to render ſea-water, which is the moſt limpid of all waters, perfectly opaque, a thickneſs of 256 feet is neceſſary, provided, by another experiment, the light of a flambeau was diminiſhed in the proportion of 14 to 5 in traverſing 115 inches of water contained in a tube of 9 feet 7 inches in length. Hence, according to M. Bouguer, no ſenſible light can paſs deeper than 256 feet in water*.

It appears to me, however, that the concluſion drawn by M. Bouguer is very diſtant from the truth. His experiments ſhould have been made with maſſes of glaſs of different thickneſſes, and not with ſeparate pieces applied to each other. I am perſuaded that the ſun's light would penetrate a greater thickneſs than that of theſe eighty pieces, which formed a thickneſs of no more than 47½ lines, or near 4 inches. Now, though theſe pieces he employed were of common glaſs, it is certain that a ſolid maſs of the ſame glaſs, of four inches thick, would not entirely intercept the light of the ſun, eſpecially as I know, by my own experience, that light paſſes eaſily through 6 ſolid inches of white glaſs. I believe, therefore, that the thickneſſes aſſumed by M. Bouguer ſhould be more than doubled, and that the light of the ſun penetrates 600 feet deep into the waters of the ocean; for there is another inaccuracy in M. Bouguer's experiments. He did not make the light of the ſun paſs through his tube of 9 feet 7 inches long: He employed the light of a flambeau, and thence concluded the diminution to be in the proportion of 14 to 5. But I am perſuaded, that, if the light of the ſun had been employed, this diminution would not have been ſo great, eſpecially as the light of a flambeau could only paſs obliquely, whilſt that of the ſun, by paſſing directly, would have penetrated deeper by its incidence alone, independent of its purity and intenſity. Thus, taking all circumſtances into conſideration, it appears, that, to approach the truth as near as poſſible, we ſhould ſuppoſe, that the light of the ſun penetrates the ſea to the depth of 600 feet, and that its heat reaches 150 feet deep. The light and heat muſt here be underſtood as ſenſible degrees only of theſe qualities.

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* Eſſai d'Optique ſur la gradation de la lumiére, p. 85.

That the heat of the ſun penetrates not above 150 feet deep in the waters of the ocean, I aſcertained by analogy derived from an experiment which appears to be deciſive. With a lens of 27 inches diameter by ſix inches thick at the centre, I perceived, that, by covering the middle part, the lens burnt only from the circumference as far as four inches thick, and that all the thicker part ſcarcely produced any heat. I then covered the whole lens, except an inch round the centre, and I found, that, after paſſing this thickneſs of ſix inches of glaſs, the light of the ſun had no influence on the thermometer. Hence I am warranted to preſume, that this ſame light, weakened by 150 feet thick of water, would not produce a perceptible degree of heat.

The light proceeding from the moon is unqueſtionably a reflected light of the ſun. This light, however, has no ſenſible heat, even when the rays are collected into the focus of a burning-glaſs. Neither would the light of the ſun have any heat, after paſſing through a certain depth of water; becauſe it would then be equally feeble as that of the moon. I am, therefore, perſuaded, that, by allowing the rays of the ſun to paſs through a large tube filled with water, and only 50 feet long, which is no more than a third of the depth I have ſuppoſed, this feeble light would produce no effect upon the thermometer, even though the liquor ſtood at the freezing point. From whence I may conclude, that, though the light of the ſun penetrates 600 feet in the waters of the ocean, its heat would not reach one fourth part of that depth. All the waters below this point would neceſſarily freeze, unleſs there was an internal heat in the earth, which alone can maintain their fluidity. In the ſame manner, it is proved by experience that the heat of the ſolar rays penetrates not above 15 or 20 feet deep in the earth, ſince ice is preſerved at theſe depths during the warmeſt ſummers. Hence, it is clear, that, below the baſin of the ſea, as well as under the ſuperior ſtrata of the earth, there is a perpetual emanation of heat, which ſupports the fluidity of the waters, and produces the temperature of the earth. In the interior parts of the earth, therefore, a heat exiſts which is proper to it, and which is totally independent of that communicated by the ſun.

We might confirm this general fact by a number of particular ones. Every man has remarked, that the ſnow melts in all places where the vapours of the interior parts of the earth have a free iſſue, as over pits, covered aqueducts, vaults, ciſterns, &c. while in all other places, where the earth, bound up by the froſt, intercepts theſe vapours, the ſnow not only remains, but, inſtead of melting, freezes. This circumſtance is alone ſufficient to ſhow, that theſe emanations from the internal parts of the earth have a real and ſenſible degree of heat.

With regard to the *fourth* fact: After the ſatisfactory proofs we have given in ſeveral articles of our *Theory of the Earth*, it is apparent, that the materials of which this globe is compoſed are of the nature of glaſs. This general truth, which we can prove by experience, was not altogether unknown to Leibnitz, a German philoſopher, whoſe name will continue to be an honour to his country :

‘Sane pleriſque creditum et a ſacris etiam ſcriptoribus inſinuatum eſt, conditos in abdito telluris ignis theſauros. . . Adjuvant vultus, nam omnis ex fuſione SCORIAE VITRI eſt GENUS . . . Talem vero eſſe globi noſtri ſuperficiem (neque enim ultra penetrare nobis datum) reapſe experimur, omnes enim terrae et lapides igne vitrum reddunt . . . nobis ſatis eſt admoto igne omnia terreſtria in VITRO FINIRI. Ipſa magna telluris oſſa nudaeque illae rupes atque immortales ſilices cum tota fere in vitrum abeant, quid niſi concreta ſunt ex fuſis olim corporibus et prima illa magnaque vi quam in facilem adhuc materiam exercuit ignis naturae . . . . cum igitur omniaque non avolant in auras tandem funduntur, et ſpeculorum imprimis urentium ope, vitri naturam ſumant, hinc facile intelliges vitrum eſſe velut TERRÆ BASIN, et naturam ejus caeterorum plerumque corporum larvis latere. *G. G. Leibnitii* protogaea. *Goettingae*, 1749, pag. 4. et 5.’

The baſis of minerals, of vegetables, and of animals, conſiſts of vitrifiable matter ; for all their *reſidua* may be ultimately converted into glaſs. The ſubſtances called *refractory* by chymiſts, and which they conſider as not fuſible, becauſe they reſiſt the action of their furnaces without being changed into glaſs, may notwithſtanding be vitrified by the more intenſe heat of burning glaſſes. Hence all the materials of this globe, at leaſt all thoſe which are known to us, have glaſs for their baſis, and may be ultimately reduced to their primitive ſtate.

We have, therefore, proved the original liquefaction by fire of the whole maſs of this globe, agreeably to the moſt rigorous rules of logic: 1. *A priori*, by the firſt fact, namely, the elevation of the earth at the equator, and its depreſſion at the poles. 2. *Ab actu*, by the ſecond and third fact, namely, the internal heat of the globe which ſtill ſubſiſts: 3. *A poſteriori*, by the fourth fact, which ſhows the effect of this action of fire, *i. e.* glaſs in all terreſtrial ſubſtances.

But, though the materials which compoſe this globe have originally been of a vitreous nature, and may all be reduced to glaſs, they ought to be diſtinguiſhed from each other with regard to the different ſtates in which they are found before they are converted into glaſs by the action of fire. They ſhould, in the firſt place, be divided into vitrifiable and calcarious ſubſtances. The firſt undergo no change by fire, unleſs it be puſhed to ſuch a degree of intenſity as is ſufficient to reduce them to glaſs; but an inferior degree of heat reduces the others to lime. The quantity of calcarious ſubſtances, though very conſiderable, is ſmall when compared to thoſe which are vitrifiable. The *fifth* fact above laid down proves, that calcarious bodies have been formed at a different period, and by another element; and we evidently perceive, that all the matters which have not been produced by the immediate action of the primitive fire, have been formed by the intervention of water; becauſe they are all compoſed of ſhells and other relicks of marine bodies. Under the claſs of vitrifiable ſubſtances are comprehended pure rock, quartz, ſand, free-ſtone, granite, ſlates, clays, metals, and metallic minerals. Theſe ſubſtances form the genuine baſis of the globe, and compoſe its principal and greateſt part. The whole of them have been originally produced by the primitive fire. Sand is nothing but glaſs in powder; ſlates, dried clays, pure rock, free-ſtone, and granite, are only vitreous maſſes, or vitrifiable ſand in a concreted form. Flints, cryſtals, metals, and moſt other minerals, are only diſtillations, exudations, or ſublimations of the firſt matters, all of which unfold their primitive origin and their common nature, by their aptitude of being converted into glaſs.

But calcarious ſand and gravel, chalk, brown free-ſtone, marble, alabaſtar, calcarious ſpatha, both opaque and tranſparent, in a word, every ſubſtance which can be converted into lime, do not at firſt exhibit their original nature. Though, like all the others, they proceed from glaſs, calcarious bodies have paſſed through filtres, which have changed their appearance. They have been formed by water. They are compoſed entirely of madrepores, ſhells, and other relicks of aquatic animals, which alone are capable of converting fluids into ſolids, and of transforming the water of the ſea into ſtone. Common marble and other calcarious ſtones are compoſed of entire ſhells and fragments of ſhells, of madrepores, aſtroites, &c. all the parts of which are either ſtill evident, or eaſily recogniſable. Gravel is nothing but broken fragments of marble and calcarious ſtones which froſt and the action of the air detach from the rocks; and they are equally convertible into lime. Lime may alſo be made of ſhells, chalk, and light land-ſtone. Alabaſter, and thoſe marbles which contain alabaſter, may be regarded as large ſtalactites, which are formed at the expence of other marbles and common ſtones. Calcarious ſpatha is likewiſe formed by exudation or diſtillation from calcarious ſubſtances, in the ſame manner as rock-cryſtal originates from vitrifiable matters. All this may be proved by inſpecting theſe different ſubſtances, and by examining attentively the great monuments of nature.

MONUMENT FIRST.

Shells and other productions of the ocean are found on the ſurface and in the interior parts of the earth; and all the ſubſtances called *calcarious* are compoſed of the remains of theſe marine bodies.

MONUMENT SECOND.

In examining thoſe ſhells and other marine productions found in France, Britain, German, and all the other parts of Europe, we diſcover, that moſt of the animals to which theſe remains have belonged, are not to be found in the adjacent ſeas, and that theſe ſpecies either have now no exiſtence, or are to be found only in the ſouthern ſeas. In the ſame manner, we ſee, in ſlates and other ſubſtances, at great depths, impreſſions of fiſhes and plants, none of which belong to our climates, and which either do not exiſt, or are to be met with in ſouthern climates only.

MONUMENT THIRD.

In Siberia, and other northern regions of Europe and Aſia, we find the ſkeletons, tuſks, and bones of elephants, hippopotami, and rhinoceroſes,

roſes, in quantities ſufficient to convince us, that theſe animals, which at preſent can propagate only in the ſouthern regions, formerly exiſted and propagated in northern countries; and it has been remarked, that theſe remains of elephants and other terreſtrial animals are found at inconſiderable depths below the ſurface. But ſhells and other marine bodies are buried deep in the interior parts of the earth.

MONUMENT FOURTH.

The tuſks and bones of elephants, as well as the teeth of the hippopotamus, are found, not only in the northern parts of our Continent, but likewiſe in thoſe of North America, though the ſpecies of the elephant and rhinoceros have now no exiſtence in the New World.

MONUMENT FIFTH.

In the middle of Continents, and in places moſt remote from the ſea, we find an infinite number of ſhells, moſt of which belong to animals actually exiſting in the ſouthern ocean, and ſeveral others have no known repreſentatives; ſo that their ſpecies ſeem to have been annihilated by cauſes till now unknown.

By comparing theſe monuments with the facts, we at once perceive, that the time when vitrifiable ſubſtances were formed is much more remote than that of the formation of calcarious bodies; and may now diſtinguiſh four and even five epochs of the remoteſt antiquity: The firſt, when the matter of the globe was in fuſion by fire, when the earth aſſumed its form, and the Equator was elevated and the Poles depreſſed by its rotatory motion: The ſecond, when this matter conſolidated, and formed the great maſſes of vitrifiable ſubſtances: The third, when the ſea covered the whole land now inhabited, and nouriſhed ſhell-animals, the remains of which have formed calcarious bodies: The fourth, when the waters which cover our Continents retired to their proper baſins: A fifth epoch, the indications of which are equally clear as the other four, is the time when the elephant, the hippopotamus, and other ſouthern animals, inhabited the regions of the north. This epoch is evidently poſterior to the fourth, ſince the relicks of terreſtrial animals are found near the ſurface of the earth, whilſt thoſe of marine animals are generally, and even in the ſame places, buried at great depths.

What, Will any man maintain, that elephants, and other animals now peculiar to the ſouth, have formerly inhabited the regions of the north? This fact, however ſingular and extraordinary it may appear, is not the leſs certain. Great quantities of ivory have been and daily are found in Siberia, in Ruſſia, and in other northern countries of Europe and Aſia. Theſe tuſks of the elephant are found ſome feet below the earth, or they are expoſed by the waters when they break down the banks of rivers. We find theſe tuſks and bones of the elephant in ſo many places, and in ſuch quantities, that they never could be brought into ſuch cold regions by human power. From inconteſtible and reiterated proofs, we are obliged to acknowledge, that theſe animals were formerly natives of the north, as they are now of the ſouth. What renders this fact more marvellous and more difficult to explain, we find the remains of thoſe animals, now peculiar to the ſouth of the Old Continent, not only in our northern provinces, but likewiſe in Canada and other parts of North America. In the Royal cabinet there are ſeveral tuſks and many bones of the elephant, which were found in Siberia. We have other tuſks and bones of the ſame animal which were found in France; as well as teeth of the hippopotamus diſcovered in America, near the river Ohio. Hence theſe animals, which cannot ſubſiſt in cold countries, have formerly exiſted in northern climates. Of courſe, the Frozen Zone was at that period equally warm as our Torrid Zone is at preſent; for it is impoſſible that the bodily conſtitution and real habits of theſe animals, which are the moſt permanent and invariable things in nature, ſhould ſo far change as to beſtow the temperature of the rain-deer upon the elephant. Neither can we ſuppoſe that theſe ſouthern animals, which require much heat for their ſubſiſtence, could ever live and multiply in northern regions, if the climate were equally cold as it is at preſent. M. Gmelin, who travelled in Siberia, and there collected many bones of the elephant, ſuppoſes that vaſt inundations in the ſouth had driven the elephants to the north, where they would all periſh at once by the rigour of the climate. But this cauſe is not proportioned to the effect. More ivory, perhaps, has already been brought from the north than all the elephants of India now exiſting could furniſh. Much more will be diſcovered when the vaſt deſerts of the north, which are ſcarcely known, ſhall be peopled, and the earth cultivated and dug by the hands of man. Beſides, it is extremely improbable, that theſe animals ſhould take the route which is moſt repugnant to their nature; for, if they were puſhed by inundations from the ſouth, why did they not rather fly to the eaſt and weſt? Why did they fly as far as the ſixtieth degree of north latitude, when they might have ſtopt on the road, or turned aſide to more fortunate climates? And how is it poſſible to conceive, that, by an inundation from the ſouthern ocean, the elephants were chaſed a thouſand leagues into the Old Continent, and more than three thouſand into the New? It is impoſſible that an inundation from the Indian ocean ſhould drive the elephants

lephants into Canada, or even into Siberia; and it is equally impoſſible, that they ſhould arrive in ſuch numbers as are indicated by their remains.

Diſſatisfied with this explication, I imagined that a more plauſible one might be given, and which ſhould perfectly correſpond with my theory of the earth. But, before exhibiting my ideas on this ſubject, I ſhall, to prevent miſtakes, remark, 1. That the ivory found in Siberia and in Canada unqueſtionably belongs to the elephant, and not to the morſe or ſea-cow, as ſome voyagers have pretended. In the northern regions, we likewiſe find the foſſil ivory of the morſe; but it is different from that of the elephant; and they are eaſily diſtinguiſhed by comparing their internal texture. The tuſks, the grinders, the ſcapulae, the thigh-bones, and other bones found in the northern climates, certainly belong to the elephant; it is even impoſſible to heſitate concerning the identity of the ſpecies. The large ſquare teeth diſcovered in the ſame northern countries, the grinding ſide of which reſembles the ſpade painted on cards, have every mark of the dentes molares of the hippopotamus; and thoſe enormous teeth, the grinding ſide of which is compoſed of large blunt points or protuberances, have belonged to ſome terreſtrial animal that now no longer exiſts, like the great volutes called *cornua ammonis*, which at preſent exiſt not in the ocean.

2. The bones and tuſks of theſe ancient elephants are every way as large as thoſe of the Indian elephants, to which we have compared them. This is a proof that theſe animals did not inhabit the northern regions from any neceſſity, ſince they acquired, in that ſituation, their full growth and complete dimenſions. Of this fact we may be aſcertained by the deſcriptions and dimenſions of them given by M. Daubenton under the article *Elephant*. But, ſince that time, I have had tranſmitted to me an entire tuſk and ſome fragments of foſſil ivory, the length and breadth of which greatly exceed the tuſks of the common elephant. I ſearched all the ſhops of the Paris ivory-merchants; but I found no tuſk which could be compared to that in my poſſeſſion. But, of a great number, I found only one equal to thoſe ſent from Siberia, whoſe circumference at the baſe is nineteen inches. Ivory, which is taken from living elephants, or from recent ſkeletons found in the foreſts, is denominated *raw ivory;* and the appellation of *roaſted ivory* is given to that extracted from the earth, the quality of which is more or leſs altered, according to the time it has remained under ground, or according to the quality of the earth in which it has been buried. Moſt tuſks which come from the North are ſtill very ſolid, and very fine works may be made of them. The largeſt were ſent to us by M. de L'Iſle, an aſtronomer, and member of the Royal Academy

of Sciences. He collected them in his travels through Siberia. In all the ſhops of Paris, there was not a ſingle tuſk of raw ivory which meaſured nineteen inches in circumference: They were all ſmaller. This tuſk was ſix feet and an inch in length; and it appears, that thoſe in the Royal Cabinet, which were found in Siberia, were, when entire, more than ſix feet and a half: But, as their extremities were cut off, we could only make a near gueſs at their real length.

If we compare the thigh-bones found in the ſame northern countries, we ſhall be ſatisfied that they are at leaſt equally long, and conſiderably thicker, than thoſe of the Indian elephants.

Beſides, as formerly remarked, we have made an exact compariſon of the bones and tuſks ſent from Siberia with thoſe of the ſkeleton of an elephant, and we found that all theſe bones are evidently the relicks of theſe animals. The Siberian tuſks have not only the figure, but the genuine ſtructure of elephant ivory, which M. Daubenton deſcribes in the following terms.

'When an elephant's tuſk is cut tranſverſely, 'we ſee, at or near the centre, a black point called the *heart*. But, if the tuſk is cut where it 'is hollow, there is only a round hole in the 'centre. We perceive crooked lines which ex'tend in different directions from the centre to 'the circumference, and, by croſſing, form ſmall 'lozenges. At the circumference, there is com'monly a narrow circular band. The crooked

‘ lines ramify in proportion as they recede from ‘ the centre. Hence the ſize of the lozenges is ‘ nearly the ſame throughout. Their ſides, or at ‘ leaſt their angles, are of a more lively colour ‘ than the areas, doubtleſs becauſe their ſubſtance ‘ is more compact. The band at the circum‘ference is compoſed of ſtraight and tranſverſe ‘ fibres, which, if prolonged, would terminate in ‘ the centre. It is the appearance of theſe lines ‘ and points which is conſidered as the grain of ‘ the ivory. This grain is perceptible in all ivories; ‘ but it is more or leſs diſtinct in different tuſks; ‘ and, when the grain is ſufficiently apparent, the ‘ ivory gets the name of *large grained*, to diſtin‘guiſh it from that whoſe grain is fine.’

It cannot be ſuppoſed that elephants could be tranſported into Siberia by men; for the ſtate of captivity alone, independent of the rigour of the climate, would have reduced them to a fourth or a third of the dimenſions which their remains exhibit. Of this effect we have ſufficient proof from the compariſon we have made between an entire ſkeleton of an elephant in the Royal Cabinet, which had lived ſixteen years at Verſailles, with the tuſks of other elephants brought from their native country. This ſkeleton and theſe tuſks, though of conſiderable ſize, are one half ſmaller than the tuſks and ſkeletons of theſe which live in freedom in Aſia or in Africa; and, at the ſame time, they are at leaſt two thirds ſmaller than the bones of the ſame animals found in Siberia.

3. The great quantities of ivory already diſcovered by accident in countries nearly deſert, and where no man ſearches for it, ſhow, that it is neither by one nor by ſeveral accidents, nor at one and the ſame time, that ſome individuals of this ſpecies have found their way into the northern regions, but that the ſpecies had formerly exiſted and multiplied there, in the ſame manner as they now exiſt and multiply in ſouthern latitudes.

The only queſtion, therefore, which remains to be ſolved, is, Whether there is or has been a cauſe that could ſo change the temperature of the different parts of the globe as to render the northern regions, which are now extremely cold, equally warm as the ſouthern climates?

Some philoſophers may imagine that this effect has been produced by the change in the obliquity of the ecliptic; becauſe, at firſt ſight, this change ſeems to indicate, that, as the inclination of the axis of the globe is not permanent, the earth might formerly revolve round an axis ſo different from that on which it now turns, as to make Siberia then lie immediately under the Equator. Aſtronomers have obſerved, that the change in the obliquity of the ecliptic is about 45 ſeconds in a century. Hence, by ſuppoſing this augmentation to be conſtant and ſucceſſive, 60 centuries would produce a diſtance of 45 minutes, and 3600 centuries would produce a change of 45 degrees. Such an alteration would bring back the 60th degree of latitude to the 15th, *i. e.* the country of Siberia, where the elephants formerly exiſted, to the regions of India, where they ſtill exiſt and multiply. Now, it may be ſaid, we have only to admit this long lapſe of time in order to account for the regular abode of elephants in Siberia: It is 360,000 years ago ſince the earth revolved round an axis 45 degrees diſtant from that upon which it turns at preſent: The 15th degree of latitude was then the 60th, &c.

I anſwer, that this idea, and the mode of explication which reſults from it, cannot, upon examination, be ſupported. The change in the obliquity of the ecliptic is not a conſtant and ſucceſſive diminution and augmentation. On the contrary, it is a limited variation, and ſometimes on one ſide and ſometimes on the other; and, conſequently, can never produce, on any ſide, nor in any climate, this difference of 45 degrees of inclination; for the variation in the obliquity of the earth's axis is occaſioned by the action of the planets, which alter the ſituation of the ecleptic, without affecting the equator. To take the ſtrongeſt of theſe attractions, which is that of Venus, it would require 126,000 years to make a change of 180 degrees in the ecliptic of that planet, and, of courſe, to produce an alteration of 6 degrees 47 minutes in the real obliquity of the earth's axis; ſince 6 degrees 47 minutes are the double of the inclination of the orbit of Venus. In the ſame manner, the action of Jupiter cannot, in [illegible]6000 years, change the obliquity of the ecliptic above 2 degrees 38 minutes; and ſtill this effect is in part compenſated by the preceding. Hence it is impoſſible that this change in the obliquity of the earth's axis ſhould ever amount to 6 degrees, unleſs we ſuppoſe, that the orbits of all the planets ſhould likewiſe change; a ſuppoſition which we cannot nor ought not to admit, ſince no cauſe exiſts which could produce this effect.

But I am enabled to ſolve this difficult matter, and to deduce it from an immediate cauſe. We have already ſeen, that the terreſtrial globe, when it firſt aſſumed its form, was in a ſtate of fluidity, and that the water being unable to diſſolve terreſtrial bodies, this fluidity was a liquefaction occaſioned by fire. Now, to paſs from this burning and liquified ſtate to a mild and temperate heat, time was neceſſary. The globe could not at once cool to its preſent temperature. Thus, during the firſt ages after its formation, the heat proper to the earth was infinitely greater than that which it received from the ſun; ſince it is ſtill much greater. This immenſe fire being afterwards gradually diſſipated, the polar, like all other climates, underwent ſucceſſive changes from heat to cold.

Of courſe, a certain time, or rather a long tract of time, exiſted, during which the northern regions, after having burnt like all others, enjoyed the ſame heat which at preſent is felt in the ſouthern climates. Hence theſe northern countries might and actually have been inhabited by animals now peculiar to the ſouth, and to whom this degree of heat is indiſpenſible. The fact, therefore, inſtead of being extraordinary, perfectly accords with the other facts, and is no more than a conſequence of them. Inſtead of oppoſing my theory of the earth, this fact, on the contrary, is an acceſſory proof of its reality, and confirms the moſt obſcure point I have advanced; *i. e.* when we attempt to look back into that profundity of time when the light of genius is apt to extinguiſh itſelf, and when, for want of obſervations, genius has no aid to lead us to a more remote period.

A ſixth epoch, poſterior to the other five, is that when the two Continents were ſeparated from each other. It is certain, that they were not ſeparated when the elephants lived equally in the north of Europe, Aſia, and America; I ſay, equally; for we find their bones in Siberia, in Ruſſia, and in Canada. Hence the ſeparation of the two Continents happened poſterior to the abode of theſe animals in the northern regions. But, as we likewiſe find the tuſks of the elephant in Poland, in Germany, in France, and in Italy, we muſt conclude, that, in proportion as theſe northern regions cooled, the elephants retired toward the temperate zone, where the heat of the ſun, and the greater thickneſs of the globe, compenſated the loſs of the earth's internal heat; and that, in the progreſs of time, the temperate zone having alſo become too cold, the elephant gradually migrated to the climates under the Torrid Zone, which alone have longeſt preſerved, by the greater thickneſs of the globe, a ſuperior degree of internal heat. Theſe are likewiſe the only climates where this interior heat, united with that of the ſun, is ſtill ſufficient to ſupport their exiſtence, and to permit them to propagate their ſpecies.

Independent of the ſpecimens tranſmitted from Ruſſia and Siberia, and which are preſerved in the Royal cabinet, there are many others in private collections. Vaſt numbers of them are to be ſeen in the muſaeum of Peterſburg, as appears from a catalogue printed in the year 1742. There are likewiſe many of them in the Britiſh muſaeum, in that of Copenhagen, and in ſome other collections in Britain, Germany, and Italy. This northern ivory, like the ſouthern, is uſed in manufacturing many articles of hardware, &c. Hence the great quantity of the tuſks and bones of elephants found in Siberia and Ruſſia can no longer remain a doubtful point.

M. Pallas, a learned naturaliſt, in his late journey through Siberia, found a great quantity of elephants bones, and an entire ſkeleton of a rhinoceros, which was buried a few feet only under the ſurface of the ground.

‘ Enormous bones of the elephant were lately ‘ diſcovered at Swijatoki, ſeventeen verſts ‘ from Peterſburg: They were found in a ſpot ‘ which had long been covered with water. ‘ Hence ſome prodigious revolution muſt have ‘ changed the climate, the productions, and the ‘ animals, in every quarter of the globe. Theſe ‘ medals of Nature prove, that thoſe countries ‘ which are now deſolated by the rigours of ‘ intenſe cold, have formerly enjoyed all the ad‘ vantages of the ſouthern latitudes *.’

The diſcovery of the tuſks and ſkeletons of elephants in Canada is but recent; and I was firſt informed of them by a letter from the late Mr Colliſon, fellow of the Royal Society of London, of which the following is a tranſlation.

‘ Mr George Croghan has aſſured me, that, ‘ in the courſe of his travels through the coun‘ tries bordering upon the river Ohio, in the ‘ year 1765 and 1766, about four miles ſouth‘ eaſt

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* Journal de Politique et de Literature, 5. Jan. 1776, art. *Peterſbourg.*

‘ eaſt from this river, and 640 miles diſtant ‘ from Fort du Queſne or Pitſburgh, he ſaw, in ‘ the neighbourhood of a large ſalt marſh, where ‘ the wild animals aſſemble at certain ſeaſons of ‘ the year, immenſe bones and teeth. Having ‘ carefully examined the place, he diſcovered, ‘ in a high bank on the ſide of the marſh, a ‘ prodigious number of bones, which, from ‘ their figure and magnitude, appeared to be ‘ the bones and tuſks of elephants.

‘ But, Sir, the large grinding teeth which I ‘ ſend you, were found along with theſe tuſks. ‘ There are others ſtill larger than theſe, which ‘ ſeem to indicate, and even to demonſtrate, ‘ that they belong not to elephants. How ſhall ‘ we reconcile this paradox? May we not ſup‘poſe, that there formerly exiſted a large ani‘mal which had the tuſks of an elephant and ‘ the grinders of the hippopotamus? for theſe ‘ large grinders are very different from thoſe of ‘ the elephant. From the great number of tuſks ‘ and grinders which he ſaw, Mr Croghan thinks, ‘ that there muſt have been at leaſt thirty of ‘ theſe animals buried in this place. Elephants, ‘ however, were never known in America; and ‘ it is improbable that they could be brought ‘ there from Aſia. The impoſſibity of their li‘ving in countries where the winters are ſo ri‘gorous, but where great quantities of their

‘ bones are found, makes a paradox, which ‘ your great ſagacity may perhaps explain.

‘ Mr Croghan, in the month of February ‘ 1767, ſent to different perſons in London, the ‘ bones and teeth he had collected in the years ‘ 1765 and 1766.

‘ 1. To my Lord Shelburn, two large tuſks, ‘ one of which was entire, and near ſeven feet ‘ long: Its thickneſs exceeded not that of a common tuſk of an elephant of an equal length.

‘ 2. A jaw-bone with two grinders in it, beſide ſeveral enormous ſeparate grinders.

‘ To Dr Franklin, 1. Three tuſks, one of ‘ which was about ſix feet long. It had been ‘ broke through the middle, which was corrupted, and reſembled chalk. The others were ‘ ſound. The end of one of them was ſharpened to a point, and it conſiſted of very fine ivory.

‘ 2. A ſmall tuſk, about three feet long, and ‘ as thick as a man's arm, with the depreſſions ‘ made by the muſcles and tendons, which were ‘ of a bright cheſnut colour, and appeared to be ‘ as freſh as if recently taken from the head of ‘ the animal.

‘ 3. Four grinders, one of the largeſt of ‘ which was broader than thoſe I ſent you, and ‘ had likewiſe an additional row of knobs. All ‘ thoſe preſented to my Lord Shelburn and Dr ‘ Franklin were of the ſame form, and had the 'ſame enamel, as the ſpecimens I now tranſmit 'for your examination.

'Dr Franklin lately dined with an officer, who 'had brought from the ſame place, in the neighbourhood of the river Ohio, a tuſk which was 'whiter, more luſtrous, and more entire than 'any of the others; and likewiſe a grinder ſtill 'larger than any of thoſe I have mentioned *.'

Extract from a Journal of a voyage made by Mr Croghan on the river Ohio, and tranſmitted to Dr Franklin in the month of May 1765.

'Having paſſed the great river Miame, we 'arrived, in the evening, at the place where the 'bones of elephants are found. It is about 640 'miles from Fort Pitt. In the morning, I 'went to the large marſh where the wild animals aſſemble at certain times of the year. 'We came to this place by a road beaten with 'the feet of the wild oxen, or biſons. It is about four miles ſouth-eaſt from the river Ohio. 'We ſaw a great number of bones, ſome of 'them ſcattered about, and others buried five or 'ſix feet below the ſurface. We ſaw them in a 'bank of earth along the ſide of the road. We 'found two tuſks of ſix feet in length, which 'we carried to our hut, along with other bones 'and teeth. The following year we returned 'to

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* Lettre Mr Collinſon to M. de Buffon, dated Mill-hill, near London, July 3. 1767.

‘ to the ſame place, in order to procure a great-
‘ er number of tuſks and teeth.

‘ If M. de Buffon had any queries to make ‘ upon this ſubject, I entreated him,’ ſays Mr Collinſon, ‘ to tranſmit them to me ; I ſhall ſend ‘ them to Mr Croghan, a man of integrity and ‘ parts, who will be happy to anſwer every ‘ queſtion.’ This little Memoir was ſubjoined to the letter which I have juſt now quoted, and to which I ſhall add an extract of what Mr Collinſon formerly wrote me concerning theſe American bones.

‘ About a mile and a half from the river Ohio, ‘ there are ſix enormous ſkeletons buried on end, ‘ with tuſks from five to ſix feet long, and of ‘ the ſame form and ſubſtance as elephants tuſks. ‘ They were thirty inches in circumference at ‘ the root. They tapered to a point. But, as they ‘ were broken, we could not perceive how they ‘ were joined to the jaws. A thigh-bone of the ‘ ſame animals was found entire. It weighed a ‘ hundred pounds, and was four and a half feet ‘ in length. Theſe tuſks and thigh-bones ſhow ‘ that the animal muſt have been of a prodigious ‘ magnitude. Theſe facts have been confirmed ‘ by Mr Greenwood, who ſaw the ſix ſkeletons ‘ in the ſalt-marſh. In the ſame place, he like- ‘ wiſe found large grinders, which appeared not ‘ to belong to the elephant, but rather to the ‘ hippopotamus. Some of theſe teeth he ſent to

‘ London, among others, two of which together ‘ weighed 9¼ pounds. He ſays, that the jaw-‘ bone was too heavy to be carried by two men. ‘ The interval between the orbits of the two ‘ eyes was eighteen inches. An Engliſhman, ‘ who had been taken priſoner by the ſavages, ‘ and conducted to this ſalt-marſh in order to ‘ teach them how to make ſalt by evaporating ‘ the water, declared, that, from a peculiar cir-‘ cumſtance, he remembered to have ſeen theſe ‘ enormous bones. He told, that three French-‘ men, who were breaking nuts, ſat upon a ſingle ‘ thigh-bone.’

Some time after writing theſe letters, Mr Collinſon read to the Royal Society of London two ſhort eſſays on the ſame ſubject, in which I found ſome new facts, which I ſhall relate, and add elucidations of ſuch things as may require explanation.

‘ The ſalt-marſh where the elephants bones ‘ are found is about four miles diſtant from the ‘ banks of the river Ohio; but it is more than ‘ ſeven hundred miles from the neareſt coaſt of ‘ the ſea. There is a road beaten by the wild ‘ oxen, or biſons, large enough to allow two ‘ chariots to travel abreaſt. This road directly ‘ leads to the great ſalt-marſh where theſe ani-‘ mals, as well as ſtags and other ſpecies of the ‘ deer, aſſemble at a certain ſeaſon of the year ‘ to lick the earth and drink the ſalt water. . . .

'The elephants bones are found in a bank of 'about ſix or ſeven feet high, which ſurrounds 'the marſh. There we ſee teeth and bones 'which had formerly belonged to ſome animals 'of a prodigious ſize. Some of the tuſks are 'near ſeven feet in length, and conſiſt of excellent ivory; and therefore we cannot entertain 'any doubt that they really belong to the elephant ſpecies. It is ſingular, however, that, 'among theſe tuſks, we never meet with a ſingle grinder of an elephant, but a vaſt number 'of enormous teeth, each of which has five or 'ſix blunt knobs, and muſt have belonged to 'ſome animal of an immenſe ſize. Theſe ſquare 'teeth have no reſemblance to the grinders of 'the elephant, which are flat, and four or five 'times broader than thick; ſo that theſe enormous grinders have no reſemblance to the 'teeth of any known animal.'

This laſt remark of Mr Collinſon is extremely juſt: Theſe large grinders are totally different from thoſe of the elephant; and, by comparing them with the grinders of the hippopotamus, which they reſemble by their ſquare figure, we ſhall perceive that they likewiſe differ in ſize, as they are two, three, and even four times more voluminous than the largeſt teeth of the ancient hippopotami found in Siberia and Canada, though theſe laſt teeth are three or four times larger than thoſe of the hippopotami which now exiſt. All the teeth which I have examined in four heads of theſe animals preſerved in the Royal Cabinet, have the grinding ſide hollowed in the form of a card-ſpade, and thoſe found in Canada and Siberia have the ſame character, and differ from them in ſize only. But thoſe enormous teeth with large blunt knobs have always four and ſometimes five rows; whilſt the largeſt teeth of the hippopotamus have only three, as may be ſeen by comparing the figures of plate CII. CIV. and CV. with thoſe of plate CVI. It ſeems, therefore, to be certain, that theſe large teeth have never belonged either to the elephant or to the hippopotamus: The difference in ſize, though enormous, would not prevent us from regarding them as pertaining to this laſt ſpecies, if all the characters in their form were the ſame; ſince we know, as formerly remarked, other ſquare teeth three or four times larger than thoſe of the preſent exiſting hippopotami, and which, having the preciſe ſame characters, are unqueſtionably the teeth of hippopotami that have been three times larger than thoſe whoſe heads are in the Royal Cabinet. I meant thoſe large teeth, which really belong to the hippopotamus, when I remarked, that they were equally found in both Continents, as well as the tuſks of the elephant. It is remarkable, however, that we not only find real tuſks of the elephant, and real teeth of the large hippopotamus, in Siberia and Canada, but we likewiſe find in the ſame countries thoſe enormous teeth with four rows of large blunt knobs. We may, therefore, conclude, that this immenſe animal no longer exiſts, and that the ſpecies is entirely extinct.

M. le Compte de Vergennes, miniſter and ſecretary of ſtate, was ſo obliging as to give me, in the year 1770, the largeſt of all theſe teeth, which is repreſented in plates CII. and CIII.; it weighed eleven pounds four ounces. This immenſe tooth was diſcovered in making a ditch in Little Tartary. There were other bones which could not be collected, and, among theſe, a thigh-bone, of which one half only was entire, and the cavity of this half contained fifteen Paris pints of water. M. l'Abbé Chappe, of the Academy of ſciences, brought me from Siberia a ſimilar tooth, but ſmaller, and which weighed only three pounds twelve and a half ounces. (Plate CIV. fig. 1. and 2.) Laſtly, the largeſt of thoſe tranſmitted to me by Mr Collinſon, and which is repreſented, (plate CV.) was found, among ſeveral others, near the river Ohio in America; and they perfectly reſemble other ſpecimens brought from Canada.

From all theſe facts it is apparent, that, independent of the elephant and hippopotamus, whoſe relicks are equally found in the two continents, another animal common to both has formerly exiſted, the ſize of which has greatly exceeded that of the largeſt elephants; for the ſquare form of theſe enormous grinders ſhows, that they were numerous in each jaw; and ſuppoſing there were only ſix or even four in each ſide of the jaws, we may form ſome notion of the magnitude of a head which could contain ſixteen grinders, each weighing ten or eleven pounds. The elephant has only four grinders, two on each ſide. They are flat, and occupy the whole jaw; and theſe two flat grinders of the elephant ſurpaſs by two inches only the breadth of the largeſt ſquare tooth of the unknown animal, which is double the thickneſs of thoſe of the elephant. Thus every cicumſtance leads us to think, that this ancient ſpecies, which ought to be regarded as the largeſt of all terreſtrial animals, exiſted during the firſt ages only; for an animal much larger than the elephant could not be ſo concealed in any part of the earth as to remain perfectly unknown. Beſides, it is evident, from the figure of theſe teeth, as well as from the enamel, and the diſpoſition of their roots, that they have no relation to the teeth of the cetaceous tribes; and that they have really belonged to a land-animal whoſe ſpecies made a nearer approach to that of the hippopotamus than to any other.

In the courſe of his eſſay, Mr Collinſon informs us, that ſeveral members of the Royal

Society were equally well acquainted with the elephants tuſks daily found in Siberia, upon the banks of the Oby, and other rivers of that country. What ſyſtem, he adds, can be formed, which will, with any degree of probability, account for thoſe bones of the elephant found in Siberia and in America? He concludes with enumerating the weight and dimenſions of all the teeth brought from the ſalt-marſh near the river Ohio, the largeſt of which belonged to Captain Ourry, and weighed ſix pounds and a half.

Mr Collinſon, in his ſecond eſſay, read before the Royal Society of London December 10. 1767, remarks, that, as one of the tuſks found in the ſalt-marſh was ſtriated or furrowed near the thickeſt end, he entertained ſome doubts whether theſe furrows were peculiar to the elephant ſpecies. To ſatisfy himſelf on this head, he viſited the warehouſe of a merchant who dealt in all kinds of teeth; and, after examining them, he diſcovered that there were as many tuſks furrowed as ſmooth at the thick end; and, of courſe, he had no difficulty in pronouncing, that the tuſks found in America were, in every reſpect, ſimilar to thoſe of the African and Aſiatic elephants. But, as the large American ſquare teeth have no relation to the grinders of the elephant, he thinks, that they are the remains of ſome enormous animal which had tuſks like an elephant, and grinders peculiar to its own ſpecies, their magnitude and form being totally different from thoſe of any known animal *.

In the year 1748, M. Fabri, who had made great excurſions into the northern parts of Louiſiana and the ſouthern regions of Canada, informed me, that he had ſeen heads and ſkeletons of an enormous quadruped, called by the Savages the *father of Oxen*; and that the thigh-bones of theſe animals were from five to ſix feet in length. Some time after, and previous to the year 1767 ſpecimens of theſe large teeth belonging to the unknown animal, as well as thoſe of the hippopotamus, and bones of the elephant, all found in America, were tranſmitted to Paris. The number of them is too conſiderable to leave any doubt that theſe animals formerly exiſted in the northern regions of America, as well as in thoſe of Europe and Aſia.

But elephants have likewiſe exiſted in all the temperate countries of our Continent. I mentioned tuſks found in Languedoc near Simore, and thoſe diſcovered in Cominges in Gaſcony. To theſe I ſhall add the largeſt and fineſt of the whole, lately ſent to the Royal Cabinet by the Duc de la Rochefoucauld, whoſe zeal for promoting ſcience is a reſult of his general knowledge. This excellent ſpecimen he found, along with M. Deſmarets of the Academy of Sciences,

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* Phil. Tranſ. 1767.

ences, when viewing the fields in the environs of Rome. This tuſk was divided into five fragments, which the Duc de la Rochfoucauld ordered to be collected. One of theſe fragments was ſtolen by the porter who had the charge of it, and there remained only four, which were about eight inches in diameter. When laid together, theſe four fragments were ſeven feet in length; and we learn from M. Deſmarets, that the fifth fragment, which was loſt, was near three feet long. Hence the total length of the tuſk muſt have been about ten feet. By examining the broken ends, we diſcovered every character of elephantine ivory; though, by being long buried under ground, it has become light and friable, like all other foſſil ivories.

M. Tozzetti, a learned Italian naturaliſt, relates, that there were found, in the valleys of Arno, the bones of elephants and other terreſtrial animals in great quantities, ſcattered here and there in the ſtrata of the earth. We may, therefore, he remarks, conclude, that elephants were formerly natives of Europe, and eſpecially of Tuſcany*.

'We found,' ſays M. Caliellini, 'about the 'end of November 1759, in a country eſtate 'belonging to the Marquis de Petrella, ſituated 'at Fuſigliano in the territory of Cortona, a

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* Extrait d'une lettre du Docteur Tozzetti, Journal étranger, mois de Decembre 1755.

‘ fragment of an elephant’s bone moſtly encruſted with a ſtony matter. . . . . Similar foſſil ‘ bones have formerly been diſcovered in our ‘ environs.

‘ In the cabinet of M. Galeotto Corazzi, there ‘ is another large portion of a petrified elephant’s ‘ tuſk, which was lately found in the neighbourhood of Cortona, at a place called *la Selva*. . . ‘ Having compared theſe fragments with a piece ‘ of an elephant’s tuſk lately brought from Aſia, ‘ we found that the reſemblance between them ‘ was perfect.

‘ In the month of April laſt, M. l’Abbé Mearini brought me an entire jaw-bone of an elephant, which he had found in the diſtrict of ‘ Farneta, a village belonging to this dioceſe. ‘ This jaw-bone is moſtly petrified, and particularly on the two ſides, where the ſtony incruſtation riſes an inch above the ſurface, and ‘ has all the hardneſs of a ſtone.

‘ Laſtly, I am indebted to M. Muzio Angelieri ‘ Alticozzi, a gentleman of this town, for a ‘ thigh-bone of an elephant, which is almoſt ‘ entire. He diſcovered it in one of his country ‘ eſtates called *Rota*, which is ſituated in the ‘ territory of Cortona. This bone is a Florence ‘ fathom long, and is likewiſe petrified, particularly in the upper extremity, called the head *.’

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* Lettre de M. Louis Coltellini de Cortone ; Journal étranger, mois de Juillet 1761.

In the ſame manner, we find in France, and in all the other nations of Europe, ſkeletons and vertebrae of marine animals, which can only ſubſiſt in the moſt ſouthern ſeas. The ſame change of temperature, therefore, has happened in the various parts of the ocean as well as in thoſe of the land; and this ſecond fact, like the firſt, as it proceeds from the ſame cauſe, confirms the whole.

When we compare thoſe ancient monuments of the firſt age of animated nature with her actual productions, we evidently perceive that the conſtituent form of each animal has remained the ſame, and that there is no alteration in the principal parts of their ſtructure. The type of each ſpecies has ſuffered no change. The internal mould has invariably preſerved its form. However long we may ſuppoſe the ſucceſſion of time, whatever number of generations may have paſſed, the individuals of each kind ſtill exhibit the ſame forms as thoſe of the firſt ages, eſpecially in the larger ſpecies, whoſe characters are more fixed, and whoſe nature is more permanent; for the inferior ſpecies have, as formerly remarked, been ſenſibly affected by the different cauſes of degeneration. We muſt, however, remark, with regard to the larger ſpecies, ſuch as the elephant and hippopotamus, that, by comparing their ancient remains with thoſe of our times, we, in general, perceive that theſe animals

nimals were then much larger than they are at preſent. Nature was then in her primitive vigour. The internal heat of the earth beſtowed on its productions all the vigour and magnitude of which they were ſuſceptible. The firſt ages produced giants of every kind. Dwarfs and pigmies ſucceeded, after the earth had cooled; and if, as other monuments ſeems to indicate, ſome ſpecies of animals, which formerly exiſted, are now loſt, this effect could only be produced, becauſe their nature required a greater degree of heat than what is now felt in the torrid zone. Thoſe enormous and nearly ſquare grinders with blunt knobs, thoſe large cornua ammonis, of which ſome are ſeveral feet in diameter, and many other foſſil fiſhes and ſhells, which no longer have any living repreſentatives, exiſted only in thoſe primitive times when the earth and ſea were ſtill warm, and produced and nouriſhed animals to whom this degree of heat was neceſſary, and who exiſt not at preſent, becauſe they have probably periſhed by cold.

To know all the petrifactions of which there are no living repreſentatives, would require long ſtudy and an exact compariſon of the various ſpecies of petrified bodies, which have been found in the bowels of the earth. This ſcience is ſtill in its infancy. We are certain, however, that there are many of thoſe ſpecies, ſuch as, the cornua ammonis, ortoceratites, lenticular and numiſmal ſtones, belemnites, Judaic ſtones, anthropomorphites, &c. which cannot be referred to any ſpecies now exiſting. We have ſeen cornua ammonis of two and three feet in diameter; and we have been aſſured by men worthy of credit, that a cornua ammonis has been found in Champagne larger than a mill-ſtone, ſince it was eight feet in diameter and one foot thick. I had an offer of its being ſent to me. But the enormous weight of this maſs, which is 8000 pounds, and its great diſtance from Paris, prevented me from accepting the preſent. Theſe examples, and others which might be given, are ſufficient to ſhow, that many ſpecies of ſhell and cruſtaceous animals formerly exiſted in the ſea, of which there are now no living repreſentatives. The ſame obſervation is applicable to ſome of the ſcaly fiſhes. Moſt of thoſe found in certain ſlates have ſo little reſemblance to the fiſhes with which we are acquainted, that their ſpecies cannot be aſcertained. Even thoſe in the Royal Cabinet, which are perfectly preſerved in maſſes of ſtone, cannot be referred to any of our known ſpecies. It appears, therefore, that the ſea formerly nouriſhed many genera, whoſe ſpecies no longer exiſt.

But, with regard to terreſtrial animals, we have only a ſingle example of a loſt ſpecies, and it appears to have been the largeſt, without excepting even the elephant: And, ſince the examples of loſt ſpecies are more rare in land than in marine animals, is it not probable, that the production of the former was poſterior to that of the latter?

From theſe facts and monuments we may perceive ſix ſucceſſive epochs in the firſt ages of Nature; ſix ſpecies of duration, the limits of which, though indeterminate, are not the leſs real; for theſe epochs are not, like thoſe of civil hiſtory, marked by fixed points, or limited by centuries and other portions of time which admit of an exact meaſurement. They may, however, be compared between themſelves, and their relative duration may be eſtimated by other facts and monuments, which indicate contemporary dates.

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After finiſhing his preliminary diſcourſe, the Count de Buffon proceeds to ſtate the different epochs of Nature, which he divides into ſeven great periods.

EPOCH FIRST.

When the Earth and Planets firſt aſſumed their proper Form.

EPOCH SECOND.

When the fluid matter conſolidated, and formed the interior rock of the globe, as well as thoſe great vitrifiable maſſes which appear on its ſurface.

EPOCH THIRD.

When the waters covered all the Continents.

EPOCH FOURTH.

When the waters retired, and Volcano's began to act.

EPOCH FIFTH.

When the elephants, and other animals of the ſouth, inhabited the northern regions.

EPOCH SIXTH.

When the Continents were ſeparated from each other.

EPOCH SEVENTH, and laſt.

When the power of Man aſſiſted the operations of Nature.

Theſe epochs are purely hypothetical, and depend more or leſs on the notion, that the earth and planets were originally driven from the body of the ſun by the impulſe of a comet, and, of courſe, remained long in a ſtate of liquid fire. We ſhall therefore content ourſelves with having barely mentioned them, and proceed to enumerate ſome facts and poſitions, which, though applied in ſupport of a fanciful ſyſtem, are curious, and may be uſeful.

The Count de Buffon remarks, that the cavities and eminences of the globe have been encruſted, and ſometimes filled with metallic ſubſtances, which are ſtill found in theſe ſituations.

'Metallic veins,' ſays M. Eller, 'are found 'only in elevated places, in a long chain of 'mountains. This chain of mountains is al'ways ſupported by a baſis of hard rock. As 'long as this rock preſerves its continuity, there 'is no chance of diſcovering metallic veins. 'But, when we meet with crevices or fiſſures, 'we then entertain hopes of finding metal. 'Mineralogiſts have remarked, that, in Ger'many, the moſt favourable ſituation is when 'the mountains riſe gradually, ſtretch toward 'the ſouth-eaſt, and, after attaining their 'greateſt elevation, deſcend gently toward the 'north weſt. . . .

'It is generally in a rugged rock, the extent 'of which is often unlimited, but ſplit into

‘ fiſſures, that metals are found ſometimes pure, ‘ but generally in the ſtate of ores. Theſe fiſ‘ſures are commonly encruſted with a white ‘ ſhining ſubſtance called *quartz* by the miners: ‘ When heavier, but ſoft and laminated nearly ‘ like chalk, it receives the denomination of ‘ *ſpar*. It is ſurrounded, on the ſide next the ‘ rock, with a kind of ſlime, which ſeems to ‘ nouriſh theſe quartzy or ſparry earths. Theſe ‘ two coverings ſerve as a ſheath for the vein. ‘ The more perpendicular the vein, the more is ‘ to be expected from it. Whenever the miners ‘ find a perpendicular vein, they ſay that it ‘ will be very productive.

‘ In theſe fiſſures and cavities, metals are form‘ed by a perpetual and pretty ſtrong evaporation. ‘ The vapours which iſſue from mines ſhow ‘ that this evaporation is ſtill going on. Fiſſures ‘ which have no exhalation are commonly bar‘ren of metal. The moſt certain proof that the ‘ exhaling vapours carry along with them mi‘neral particles, and apply them to the ſides of ‘ the fiſſures, is that ſucceſſive encruſtation which ‘ is apparent in the whole circumference of ‘ theſe fiſſures or hollows of rocks, till their ca‘vities are completely filled, and the ſolid vein ‘ is formed. This fact is ſtill farther confirmed ‘ by the tools left in theſe hollows; and, ſeveral ‘ years after, they are found to be encruſted ‘ with metal.

'The fiſſures which furniſh the moſt rich 'veins of metal always incline to a perpendicular 'direction. In proportion as the miners de'ſcend, the temperature of the air is always 'warmer; and the exhalations are ſometimes ſo 'abundant, and ſo noxious, that, in order to 'avoid ſuffocation, the miners are obliged to 'fly to the pits or galleries, otherwiſe they 'would be inſtantly deſtroyed by the arſenical 'and ſulphureous particles. Sulphur and arſenic 'are commonly found in the four imperfect, 'and in all the ſemimetals, and it is from theſe 'they receive their metallic form.

'Gold, and ſometimes ſilver and copper, are 'the only metals which are found pure in any 'quantities. But, in general, copper, iron, 'lead, and tin, when taken out of the veins, 'are mineralized with ſulphur and arſenic. We 'know from experience, that metals loſe their 'metallic form by degrees of heat proportioned 'to each ſpecies. This deſtruction of the metal'lic form, which the four imperfect metals under'go, ſhows that the baſis of metals is an ear'thy matter; and, as theſe calces, as well as the 'calcarious and gypſeous earths, vitrify by the 'application of a certain degree of heat, we 'are certain that metallic earth belongs to the 'claſs of vitrifiable earths *.

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* Mem. de M. Eller ſur l'origine et la generation des Metaux.

M. Lehman, a celebrated chymiſt, is the firſt perſon who ſuſpected that metallic ſubſtances had a double origin. ‘Gold and ſilver,’ he remarks, ‘are found in maſſes only in the mountains ‘which have veins, and iron is found only in ‘thoſe mountains which have regular ſtrata. ‘All the ſmall pieces of gold and ſilver found ‘in the mountains with ſtrata have been detached from veins in the ſuperior mountains in ‘the neighbourhood of the former.

‘Gold is never in the form of ore. It is always found in a native or virgin ſtate, though ‘it is often ſcattered about in particles ſo minute, that it cannot be diſtinguiſhed even by ‘the beſt microſcopes. In the mountains with ‘ſtrata, no gold, and very little ſilver, are to be ‘found. Theſe two metals belong excluſively ‘to mountains with veins. Sometimes, however, we find ſilver in ſmall leaves, or under ‘the form of hair, in ſlate. Native copper oftener occurs in ſlate; and this copper is alſo ‘commonly in the form of threads or hair.

‘A few years after iron-ores have been taken from the earth, they are reproduced. ‘They are not found in the mountains with ‘veins, but in thoſe with ſtrata. Iron is ſeldom, if ever, met with in a native ſtate.

‘With regard to native tin, it has no exiſtence in Nature, and is only produced by the ‘aſſiſtance of fire. The ſame remark is appli-

'cable to lead, though the grains found in Sileſia have been conſidered as native lead.

'Native mercury is found in ſtrata of fat argillaceous earth, or in ſlate.

'The ſilver ores found in ſlate are not nearly 'ſo rich as thoſe found in the mountains with 'veins. This metal is found in beds of ſlate; 'and is always in the form of minute particles, 'threads, or ramifications, but never appears in 'large maſſes. Theſe beds of ſlate muſt likewiſe be adjacent to the mountains with veins. 'The ſilver-ores found in ſtrata are never in a 'ſolid or compact form. All the other ores, 'which contain much ſilver, are peculiar to the 'mountains with veins. There is a great deal 'of ſilver in the ſtrata of ſlate; and it is alſo 'ſometimes found in pit-coal.

'Tin is the metal which moſt rarely appears 'in ſtrata; lead is more common in that ſituation. We find it attached to ſlate, but never 'to coal.

'Iron is almoſt univerſally diffuſed, and is 'found in beds under a number of different 'forms.

'Cinnabar, cobalt, biſmuth, and lapis calaminaris, are likewiſe commonly found in beds.

'Pit-coal, jett, amber, and aluminous earth, 'are produced by vegetables, and eſpecially by 'reſinous trees which have been buried in the 'earth, and have been more or leſs decom-

'poſed; for we often find, above the ſtrata of 'coal, wood which is not totally decompoſed; and 'it is ſtill more decompoſed as we deſcend deep'er. Slate, which covers coal, is often full of the 'impreſſions of plants, ſuch as ferns, maiden'hair, &c. It is remarkable, that all theſe im'preſſions belong to foreign plants, and the wood 'likewiſe appears to be foreign. Amber, which 'ought to be regarded as a vegetable reſin, often 'includes inſects, which, when attentively ex'amined, belong not to the climate where they 'now exiſt. Aluminous earth is frequently la'minated, and reſembles wood ſometimes more 'and ſometimes leſs decompoſed.

'Sulphur, alum, and ſal ammoniac, are found 'in beds formed by volcano's.

'Petroleum and naphtha indicate a ſubterra'neous fire, which produces a diſtillation from 'pit-coal. We have examples of theſe ſubter'raneous fires which act ſilently, in the coal 'ſtrata of Britain and Germany. They burn 'long without any exploſion; and it is in the 'neighbourhood of theſe ſubterraneous fires 'that hot ſprings are found.

'The mountains which contain veins include 'neither coal nor bituminous and combuſtible 'bodies: Theſe ſubſtances are found only in the 'mountains with ſtrata.'

In the ſecond epoch of Nature, the Count de Buffon remarks, 'that, in the northern re'gions

'gions there are mountains compoſed entirely 'of iron.' I mention, ſays he, by way of example, the iron mines near Taberg in Smoland, a part of the iſland of Gothland in Sweden. It is the moſt remarkable of thoſe mines, or rather mountains of iron which have the quality of yielding to the attraction of the load-ſtone; which proves that they have been formed by the action of fire. The baſis of this mountain is a very fine ſand. Its height is more than 400 feet, and its circumference about one league. It is compoſed entirely of a rich ferruginous matter, and we even find in it native iron, which is another proof that it has undergone the action of a violent fire. This ore, when broken, exhibits ſmall ſhining particles, which ſometimes croſs each other, and ſometimes are arranged like ſcales. This mine has been wrought above two hundred years.

The ore in this mountain is not diſpoſed in regular beds; neither is the iron every where of equal goodneſs. Through the whole mountain there are fiſſures ſometimes perpendicular, and ſometimes horizontal: Theſe are all filled with ſand, which contains no iron. This ſand is pure, and of the ſame ſpecies with that on the ſea-coaſt. In this ſand, we ſometimes find the bones of animals, and the horns of ſtags, which ſhows that the ſand has been carried thither by the waters, and that the formation of this iron mountain by ſire happened before the crevices and the perpendicular and horizontal fiſſures were filled with ſand.

The maſſes of ore are rolled down from the top of the mountain; but, in other mines, the minerals muſt be drawn up from the bowels of the earth. This ore muſt be broken to pieces, or pounded, before it is put into the furnace, where it is ſmelted by means of charcoal and calcarious ſtones.

This hill of iron is ſituated in an elevated and mountainous diſtrict, about eighty leagues from the ſea: It ſeems to have formerly been altogether covered with ſand *.

We are next informed, that there are mountains of load-ſtone in ſome countries, and particularly in thoſe of the North. From the foregoing example, we have ſeen that the iron mountain of Taberg riſes 400 feet above the level of the ſea. M. Gmelin, in his travels through Siberia, remarks, that, in the northern countries of Aſia, almoſt all the metallic ores are found on the ſurface of the earth, whilſt in other countries they are buried deep in the interior parts of the earth. This fact, if generally true, is a new proof that metals have been formed by the primitive fire, and that the globe being

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* Extrait d'un article de l'ouvrage periodique qui a pour titre, *Norſdilche beytrage*, &c. Contribution du Nord pour les progrés de la phyſique, des Sciences, et des arts, 1756.

ing leſs thick in the northern regions, metals were formed nearer the ſurface than in the ſouthern countries.

M. Gmelin examined the great mountain of loadſtone among the Baſchkires in Siberia. This mountain is divided into eight parts by valleys, of which the ſeventh part produces the beſt loadſtone. The ſummit of this portion of the mountain conſiſts of a yellowiſh ſtone which ſeems to partake of the nature of jaſper. We there find ſtones that have the appearance of free-ſtone, which weigh from two to three thouſand pounds; but they all have a magnetic virtue. Though covered with moſs, they fail not, at more than the diſtance of an inch, to attract iron and ſteel. The ſides expoſed to the air have the ſtrongeſt magnetic power, thoſe covered with the earth being much weaker. Thoſe parts which are expoſed to the injuries of the air are ſofter, and, conſequently, leſs proper for being armed. A large portion of loadſtone, of the ſize above mentioned, is compoſed of a number of other portions which act in different directions. To work them properly, they ſhould be ſeparated in ſuch a manner that the whole portion, which includes the virtue of each particular magnet, ſhould preſerve its unity: By obſerving this rule, we would probably obtain magnets of an uncommon ſtrength. But, as they are cut without any foreſight, many portions are of no value, either becauſe they contain little no magnetic power, or becauſe, in a ſingle piece, there are two or three magnets united: Such portions have indeed a magnetic virtue; but, as it is not directed to the ſame point, a magnet of this kind muſt be ſubject to great variations.

The loadſtone of this mountain, except what is expoſed to the air, is exceedingly hard, ſpotted with black, and full of little knots or protuberances, conſiſting of ſmall angular parts, like thoſe often obſervable on the ſurface of bloodſtone, from which it differs only in colour; but, inſtead of theſe angular parts, we ſometimes perceive a kind of ochrey earth. In general, loadſtones with theſe angular parts have leſs power than the other kinds. That part of the mountain where the loadſtones are found is compoſed almoſt entirely of a fine iron ore, which lies in ſmall portions among the loadſtones. The whole ſection of the high part of the mountain contains a ſimilar ore; but, in proportion as we deſcend, the metal is more rare. Below the ore of loadſtone, there are other ferruginous ſtones, which, if melted, would produce very little iron. Theſe ſtones have the colour of metal, and are very heavy. Their interior parts are irregular, and have nearly the appearance of ſcoriae. In their ſurfaces they pretty much reſemble loadſtones; but they have no magnetic power. Between theſe ſtones there are other pieces of rock which appear to be compoſed of ſmall particles of iron. The ſtone itſelf is heavy, but very ſoft. The interior parts reſemble burned matter, and they have little or no magnetic virtue. We likewiſe meet occaſionally with a brown iron ore in beds of an inch thick; but it yields very little metal *.

In the mountains of Poias in Siberia, there are ſeveral other mines of loadſtone. Ten leagues off the road which leads from Catharinbourg to Salikamſkaia, there is a hill called *Galazinſki*, which is more than twenty fathoms high, and is entirely compoſed of a loadſtone rock. It has the brown colour and the denſity of iron.

Twenty leagues from Salikamſkaia, we find cubical loadſtones of a brilliant greeniſh colour. When pulveriſed, the grains have the appearance of fire. It is worthy of remark, that loadſtone is found only in thoſe chains of mountains which ſtretch from ſouth to north †.

In the countries bordering upon Lapland, and on the confines of Bothnia, two leagues diſtant from Cokluanda, there is an iron-ore, from which very fine loadſtones are extracted. 'We 'admired,' ſays Regnard, 'the ſurpriſing effects

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* Extrait d'Hiſt. generale des voyages, tom. 18. p. 141. &c.

† Ibid. tom. 19. p. 472.

'of this ſtone, when it remained in its natural 'ſituation: It required a great deal of force to 'obtain pieces of the magnitude we wiſhed; and 'the large hammer employed remained ſo fixed 'to the wedge in the ſtone, that the workman 'required aſſiſtance to diſengage it. I tried the 'experiment myſelf; I took a large iron lever, 'which was ſo heavy that I could hardly ſupport it; I brought it near the wedge by which 'it was attracted and ſupported with an amazing force. I held a mariner's compaſs in the 'middle of the hole where the ore lay, and the 'needle revolved perpetually with an incredible 'rapidity *.'

In Vol. I. p. 29. I remarked, 'that, according to the relation of voyagers, the mountains 'of the north are but ſmall hills, when compared to the mountains of the equatorial regions; 'and that the general movement of the waters 'produced thoſe large mountains in the Old 'Continent, which ſtretch from eaſt to weſt, 'and from north to ſouth in the New.'

This paſſage requires explanation, as well as ſome reſtrictions. From a thouſand obſervations, it is certain, that ſhells and other productions of the ocean are found upon the whole ſurface of the inhabited parts of the earth, and even upon the mountains to a very great height.

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* Oeuvres de Regnard, tom. 1. p. 185.

I advanced, from the authority of Woodward, who firſt collected facts upon this ſubject, that ſhells were likewiſe found on the tops of the higheſt mountains. From my own obſervations, as well as thoſe of others, I know, that there are ſhells in the Alps and Pyrennees at 900, 1000, 1200, and 1500 fathoms above the level of the ſea; that they are likewiſe found in the mountains of Aſia; and, laſtly, in the Cordelieres of America, a bank of ſhells has lately been diſcovered at the height of more than 2000 fathoms above the ſea *.

It is, therefore, certain, that, in all the different parts of the world, and even to the height of 1500 or 2000 fathoms above the preſent level

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* M. le Gentil, of the academy of Sciences, wrote me the following letter, in December 1771: ‘ Don Antonia Ulloa ‘ deſired me, when departing from Cadiz, to ſend him two ‘ petrified ſhells, which, in the year 1761, he had dug out ‘ of the mountain that contains the quick ſilver mines. This ‘ mountain is in the government of Ouanca-Velica in Peru. ‘ Its ſouthern latitude is from 13 to 14 degrees. At the ‘ place where theſe ſhells are found, the mercury ſtood at 17 ‘ inches 1¼ line, which correſponds to the height of 2222⅓ ‘ fathoms above the level of the ſea.

‘ At the top of the mountain, which is far from being the ‘ higheſt in this canton, the mercury ſtands at 16½ inches, ‘ which implies a height of 2337⅔ fathoms.

‘ In the town of Ouanca-Velica, the mercury ſtands at 18 ‘ inches 1½ line, which gives a height of 1949 fathoms.

‘ Don Antonio Ulloa informed me, that he detached theſe ‘ ſhells from a very thick bank, the extent of which he did ‘ not know: The ſhells are of the large pilgrim or ſcallop ‘ kind.’

vel of the ſea, the ſurface of the globe has been covered with the waters, and that they remained long enough for the production and multiplication of ſhell-animals; for the quantity of them is ſo great, that their ſpoils often form large banks, which extend many miles in length. They compoſe a conſiderable part of the exterior ſtrata of the earth; for calcarious ſubſtances, or the ſpoils of ſhells, are very common in moſt countries. But, at high points of elevation, *i. e.* above 1500 or 2000 fathoms, the ſummits of the mountains generally conſiſt of pure rock, granite, and other vitrifiable bodies produced by the primitive fire, which contain no ſhells, madrepores, or any thing that has a relation to calcarious ſubſtances. We may, therefore, conclude, that the ſea has never reached, or at leaſt for a ſhort time only, thoſe moſt elevated parts of the earth.

To ſupport the teſtimony of Don Ulloa, concerning the ſhells found in the Cordelieres, we ſhall add that of Alphonſo Barba. He tells us, that, in the moſt mountainous part of Peru, there are ſhells of all ſizes, ſome of them concave, others convex, and the whole finely impreſſed *. Hence America, as well as the other quarters of the globe, has been covered with the waters of the ſea. The firſt obſervers were probably induced to think that no ſhells were to be found in the Cordelieres, becauſe moſt of theſe mountains, which are the higheſt on this globe, are either active or extinguiſhed volcano's, the eruptions of which have covered all the adjacent countries with burned ſubſtances: Of courſe, all the ſhells which might have been found there, are not only buried, but completely deſtroyed. It is not, therefore, ſurpriſing that no marine productions have been diſcovered around theſe mountains, which either are at preſent, or have formerly been volcano's; for the territories which ſurround theſe mountains muſt be compoſed entirely of aſhes, ſcoriae, glaſs, lava, and other burned or vitrified bodies. Thus the notion that the ſea never covered the mountains, has no other foundation than this circumſtance, that, on the tops of ſeveral of them, no ſhells or other productions of the ſea are now to be ſeen. But, as we find, in an infinite number of places, and even as high as 1500 or 2000 fathoms, ſhells and other ſea-bodies, it is evident, that there are few ridges of mountains which have not been covered with the ocean; and that the ſpots where no ſhells appear only ſhow that the animals which produce them have never dwelt there, or that the motion of the waters has not tranſported thither marine productions, as it has done in every other part of the globe.

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* Metallurgie d' Alphonſo Barba, tom. 1. p. 64.

We are next informed, that ſome fiſhes and plants can live and vegetate in waters ſo hot as from 50 to 60 degrees of the thermometer. There are many examples of plants growing in the hotteſt bath-waters; and M. Sonnerat found fiſhes in water the heat of which was ſo great that he durſt not plunge his hand into it. 'Two 'leagues from Calamba,' ſays he, 'I found in 'the iſle of Luçon, near the village of Bally, a 'brook, the water of which was ſo hot that 'Reaumur's thermometer, when plunged into 'it, about a league from its ſource, ſtood at 'the 69th degree. Upon perceiving ſuch a 'degree of heat, I imagined, that all the produc-'tions of nature muſt have been extinguiſhed 'upon the margin of this brook. But I was 'much ſurpriſed when I ſaw three vigorous 'ſhrubs, the roots of which were immerſed in 'this boiling water, and their branches ſur-'rounded with its vapour. The heat was ſo 'great, that, when the ſwallows attempted to 'croſs the water at ſeven or eight feet high, they u-'niformly fell down dead. One of theſe ſhrubs 'was an *agnus caſtus*, the other two were a 'ſpecies of broom called *aſpalathus*. During my 'abode in this village, I conſtantly drank this wa-'ter after it was cooled. Its taſte ſeemed to be 'earthy and ferruginous. Several baths are con-'ſtructed along this brook, and their degrees of 'heat are proportioned to their diſtance from its 'ſource. When I viſited the firſt bath, my 'ſurpriſe was increaſed: In this water, which 'was ſo hot that I durſt not plunge my hand 'into it, I ſaw fiſhes ſwimming. I uſed every 'effort to procure ſome of them; but their agi'lity, and the want of addreſs in the people, 'prevented me from ſucceeding. I examined 'them in the water; but I could not diſtinguiſh 'their genus, on account of the vapour riſing 'from the water. They had brown ſcales, 'and the largeſt of them were about four inch'es long. I could not learn how theſe fiſhes 'had got into the baths.' The teſtimony of M. Sonnerat is ſtrengthened by that of M. Prevoſt, who travelled with him into the interior parts of the iſle of Luçon. 'You was right,' M. Prevoſt remarks, 'to communicate to M. de 'Buffon the obſervations you collected when 'we travelled together. You deſire me to con'firm in writing what ſurpriſed us ſo much in 'the village of Bally, ſituated on the margin of 'the Laguna of Manilla, at *Los-bagnos*. I am 'ſorry I have not a copy of our obſervations 'made with Reaumur's thermometer. But I 'clearly recollect, that the water of the ſmall 'brook which paſſed through this village to fall 'into the lake, made the mercury riſe to 66 'or 67 degrees, though it was plunged into the 'water at a league's diſtance from the ſource of 'the brook. The margins of this brook were 'covered with a very fine green carpet. You 'cannot have forgot the *agnus caſtus* we ſaw

'in

‘ in flower, the roots of which were moiſtened ‘ with the water of the brook, and its ſtem and ‘ branches perpetually ſurrounded with its ‘ ſteams. The curate of the village likewiſe ‘ aſſured, me that he had ſeen fiſhes in this ſame ‘ brook. This fact I cannot certify. But I ‘ ſaw fiſhes in one of the baths, the heat of ‘ which raiſed the mercury to 48 and 50 de- ‘ grees *.’

I know not whether fiſhes have ever been found in our hot waters; but it is certain that the bottom of the hotteſt of them is covered with plants. M. l’Abbé Mazéas informs us, that, in the almoſt boiling water in the Solfatara of Viterbe, the bottom of the baſin is covered with the ſame plants which grow at the bottoms of lakes and ditches †.

Of Giants,

From monuments which ſtill remain, it appears, that gigantic animals of different kinds have formerly exiſted.

The large teeth with blunt knobs which I formerly deſcribed, indicate the exiſtence of an animal, whoſe magnitude greatly ſurpaſſed that of the elephant. But this gigantic ſpecies is now entirely annihilated. Other large teeth, the grinding face of which reſembles ſpades on cards, like thoſe of the hippopotamus, and which are four times larger than the teeth of the preſent hippopotamus, ſhow that there has been a very gigantic ſpecies of this animal. The enormous thigh-bones, which far exceed the dimenſions of thoſe of our elephants, demonſtrate the ſame thing with regard to the elephant ſpecies.

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* Voyage à la Nouvelle Guineé, par M. Sonnerat, Correſpondant de l’ Academie Royale des ſciences, et du Cabinet du Roi, p. 38. &c.

† Mem. des Savans étrangers, tom. 5. p. 325.

In the year 1772, there was found, near Rome, a petrified head of an ox, which P. Jacquier deſcribes in the following manner. 'The 'length of the front between the two horns, is '2 feet 3 inches; the diſtance between the orbits of the eyes, 14 inches, and that from the 'ſuperior part of the front to the orbit of the 'eye one foot ſix inches; the circumference of 'the horn at the baſe, is one foot ſix inches; the 'length of the horn four feet; and the diſtance between the ends of the horns three 'feet. The internal part of this petrefaction 'is extremely hard. This head was found at 'Puzzolani more than 20 feet below the ſurface 'of the ground *.'

'In the year 1768, I ſaw, in the cathedral of 'Straſburg, a large horn of an ox ſuſpended by 'a chain to a pillar near the choir. It appeared to be three times bigger than thoſe of our 'largeſt oxen. As it was hung very high, I 'could not take the exact dimenſions, but I

'judged

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* Gazette de France du 25. Septembre 1772, *Article de Rome.*

'judged it to be about 4½ feet long, and from '7 to 8 inches in diameter at the baſe *.'

Lionel Waffer relates, that he ſaw, in Mexico, bones and teeth of a prodigious ſize: Among others, he ſaw a tooth 3 inches broad and 4 in length. Having conſulted the moſt intelligent people of the country, they concluded that the head could not be leſs than a yard broad †.

It is, perhaps, the ſame head which Acoſta mentions: 'I ſaw,' ſays he, 'a grinder which 'aſtoniſhed me by its enormous ſize; for it was 'as large as a man's fiſt.' P. Torquemado, a Franciſcan, relates, that he had in his poſſeſſion a grinder, twice as large as a man's fiſt, and which weighed two pounds. He adds, that, in the city of Mexico, and in the Convent of St Auguſtine, he ſaw a thigh bone ſo large, that the individual to which it belonged muſt have been from 11 to 12 cubits high, *i. e.* 17 or 18 feet; and that the head muſt have been as big as one of the large pitchers uſed in Caſtille for holding wine.

Phillippe Hernandés informs us, that there were found, at Tezcaco and Toſuca, ſeveral bones of an extraordinary magnitude; and that among theſe there are grinding teeth five inches broad and ten high; from which he concludes, that the ſize of the head muſt have been ſo enormous that two men could not have embraced it with their arms. Don Lorenzo Boturini Benaduci likewiſe tells us, that, in New Spain, and particularly in the heights of Santa-fé, and in the territories of Puebla and Ttlaſcala, they find enormous bones, and grinders, one of which, preſerved in the Royal Cabinet, is a hundred times larger than the largeſt human teeth *.

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* Note communicated to M. de Buffon by M. Grignon, Sept. 24. 1777.

† Waffer's travels in America, p. 367.

The author of this Gigantologie Eſpagnole attributes theſe enormous teeth and bones to giants of the human ſpecies. But, is it credible that men ever exiſted whoſe heads were eight or ten feet in circumference? Is it not equally aſtoniſhing that, in the ſpecies of the hippopotamus or elephant, there have been individuals of this magnitude? We are, therefore, led to think, that theſe enormous teeth are of the ſame kind with thoſe lately found in Canada near the river Ohio, which we aſcribed to an unknown animal, whoſe ſpecies formerly exiſted in Tartary, in Siberia, and in Canada, and which extended from the Illionois as far as Mexico. As the Spaniſh authors mention not that elephants tuſks were found in New Spain along with theſe large grinders, it is probable that a ſpecies different from that of the elephant formerly exiſted

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* Gigantologie Eſpagnole, par le P. Torrubia, Journal étranger, Nov. 1760.

iſted there, to which theſe large grinders belonged, and that this ſpecies was diffuſed as far as Mexico. Beſides, the large teeth of the hippopotamus ſeem to have been anciently known; for St Auguſtine tells us, that he ſaw a grinder ſo large, that, if divided, it would have made a hundred teeth of an ordinary man *. Fulgoſa likewiſe remarks, that teeth were found in Sicily, each of which weighed three pounds †.

John Sommer relates, that he found, near Chatham in Canterbury, at the depth of ſeventeen feet below the ſurface of the earth, monſtrous bones, ſome of them entire, and others broken. He likewiſe found four entire teeth, each of them weighing more than half a pound, and nearly as large as a man's fiſt. The whole four were grinders, and, except in magnitude, they pretty much reſembled human teeth. He farther remarks, that Louis Vives mentions a grinder ſtill larger, which was ſhewn him for a tooth of St Chriſtopher. He adds, that Acoſta ſaw in India a ſimilar tooth dug out of the earth, along with ſeveral other bones, which, when arranged in proper order, repreſented a man of a monſtrous ſtature. We might have formed the ſame idea, ſays Mr Sommer, concerning the teeth dug out of the earth near Canterbury, if bones

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* De Civitate Dei, lib. 15. cap. 9.

† Lib. 1. cap. 6.

bones had not been found in the ſame place, which could not belong to the human ſpecies. Several perſons who examined theſe bones, judged them to be the bones and teeth of the hippopotamus. Two of theſe teeth are engraved in the philoſophical tranſactions, No. 272. fig. 9.

From theſe facts we may conclude, that moſt of thoſe large bones found under the ſurface of the earth belong to the elephant and hippopotamus: But it ſeems to be certain, that, by comparing the enormous teeth with blunt knobs, with thoſe of the elephant and hippopotamus, they have belonged to an animal much larger than either, and that the ſpecies of this prodigious animal no longer exiſts.

Among the preſent elephants it is extremely rare to find a tuſk of ſix feet in length. The longeſt are generally from five to ſix and a half feet; and, of courſe, the ancient elephant, which produced a tuſk of ten feet long, whoſe fragments are in our poſſeſſion, was a gigantic ſpecies. The immenſe thigh-bone in the Royal Cabinet confirms the ſame concluſion.

The ſame remark is applicable to the ſpecies of the hippopotamus. I cauſed two of the largeſt grinders to be extracted from the largeſt head of the hippopotamus in the Royal Cabinet: One of them weighed ten, and the other nine and a half ounces. I then weighed two teeth, the one found in Siberia, and the other in

Canada. The firſt weighed two pounds twelve ounces, and the ſecond two pounds two ounces. Hence theſe ancient hippopotamis were gigantic when compared with thoſe now exiſting.

The example already given of the enormous petrified head of an ox, found in the environs of Rome, proves, that there have likewiſe been prodigious giants in this ſpecies of quadruped, which we are alſo enabled to ſhow, by ſeveral other monuments of antiquity. In the Royal Cabinet, we have, 1. A fine greeniſh horn, which is very ſmooth and well turned, and evidently belongs to the ox. The circumference at the baſe is 25, and its length 42 inches. Its cavity contains 11$\frac{1}{4}$ Paris pints of liquor; 2. The core, or internal bone of an ox's horn, which weighs ſeven pounds; whilſt the largeſt core of the horns of our oxen exceeds not the weight of one pound: This internal bone was preſented to the Royal Cabinet by M. le Comte de Treſſan, a man of taſte, and a good Natural hiſtorian; 3. Two internal bones of an ox's horn attached to a portion of the cranium, were found in beds of turf, at the depth of 25 feet, between Amiens and Abbeville, and tranſmitted to me for the Royal Cabinet. The whole weighed 17 pounds; and each horn-bone, when ſeparated from the cranium, weighed at leaſt 7$\frac{1}{2}$ pounds. I compared the dimenſions, as well as the weight of theſe different bones;

that of the largeſt ox to be found in Paris was only 13 inches long, and 7 in circumference at the baſe. But, of the two dug out of the earth, the one was 24 inches long, and 12 in circumference at the baſe, and the other 27 inches in length, and 13 in circumference. Theſe facts are more than ſufficient to ſhew, that, in the ſpecies of the ox, as well as in thoſe of the hippopotamus and elephant, prodigious giants have formerly exiſted.

With regard to the human ſpecies, individual giants have been produced not only in Aſia, but in every climate; for, even in our own days, we ſee gigantic men in every country. We lately ſaw a giant who was born in Finland, on the very confines of Lapland. But we are not equally certain, that permanent races, and far leſs entire nations of giants, ever exiſted. However, the teſtimony of ancient authors, and eſpecially thoſe of Holy Writ, ſeem clearly to indicate, that races of giants formerly exiſted in Aſia. In the book of Numbers, chap. 13. verſe 33. it is ſaid, *And there we ſaw giants, the ſons of Anak, which came of the giants: and we were in our own ſight as graſhoppers, and ſo we were in their ſight.* Though this deſcription may have the appearance of exaggeration, which is common in the oriental ſtyle, it is plain that theſe giants were very large.

In 2 Samuel, chap. 21. verſe 20. a giant is mentioned of the race and family of Goliah, who had ſix fingers and toes on his hands and feet: In the ſame book, there are ſeveral other paſſages which prove the exiſtence and deſtruction of giants.

In Joſhua, chap. 2. verſe 22. it is ſaid, that *there was none of* the giants of the race *of the Anakims left in the land of the children of Iſrael; only in Gaza, in Gath, and in Aſhdod, there remained.*

Philo, St Cyrillus, and ſeveral other authors, ſeem to think, that the word *giants* means only proud and impious men, and not men of an extraordinary ſtature. But there is no foundation for this opinion; ſince the amazing height and ſtrength of theſe men are often deſcribed.

The prophet Amos informs us, that the Lord *deſtroyed the Amorite, whoſe height was like the height of cedars, and he was ſtrong as the oaks.*

Ogg, king of Baſhan, was nine cubits high, and Goliah ten cubits and one palm. Ogg's bed was nine cubits, or thirteen and a half feet long, and four cubits, or ſix feet, broad. The breaſtplate of Goliah weighed 208 pounds 4 ounces, and the blade of his lance 25 pounds.

Theſe evidences are ſufficient to prove, that there formerly exiſted in the continent of Aſia, not only individuals, but races of giants, who have been deſtroyed, and the laſt of whom appeared in the days of King David. Nature, who never loſes any of her rights, ſometimes reſumes her former powers of production; for, in almoſt every climate, men of an extraordinary ſtature, *i. e.* of ſeven and a half, eight, and even nine feet high, occaſionally appear. Beſide the examples already given, many others are to be found, both in ancient and modern authors, of giants of ten, twelve, fifteen, and eighteen feet high. But theſe laſt dimenſions, I am perſuaded, ought to be greatly reduced. The bones of elephants have often been miſtaken for human bones. Beſides, Nature, in her preſent appearance, preſents no ſpecies with ſuch great diſproportions, except, perhaps, that of the hippopotamus; for the teeth of thoſe found in the bowels of the earth are at leaſt four times larger than the teeth of the hippopotamus which now exiſts.

The bones of the ſuppoſed king Teutobochus, found in Dauphiny, gave riſe to a diſpute between Habicot, a ſurgeon in Paris, and Riolan, the favous anatomiſt. Habicot, in his *Gigantoſteologie*, tells us, that theſe bones were taken out of a brick ſepulchre, 18 feet below ground, and ſurrounded with ſand. He neither gives an exact deſcription, nor the number of theſe bones. He aſſerts that they are human, becauſe they belonged to no other animal. He adds, that ſome maſons, when working to Seignio Langon, a gentleman of Dauphiny, on the 11th day of January 1613, diſcovered this tomb near the ruins of the caſtle of Chaumont; that the tomb was built with brick; that it was 30 feet long, 12 broad, and 8 high; that is was covered with a gray ſtone, on the middle of which was engraved, *Theutobochus rex*; that, when the tomb was opened, a human ſkeleton appeared, which was 25½ feet long, 10 broad at the ſhoulders, and 5 thick; that, before touching theſe bones, the head was meaſured, and it was 5 feet in length, and 10 in circumference. Here it is worthy of remark, that the proportion between the length of a human head and that of the body, is not a fifth, but a ſeventh and one half; ſo that this head of 5 feet ſuppoſes the body to have been 37½ feet in length. Laſtly, Habicot tells us, that the under jaw was 6 feet round, and the orbits of the eyes 7 inches; that each clavicle was 7 feet long; and that moſt of theſe bones, after being expoſed to the air, crumbled into duſt.

In the ſame year 1613, Dr Riolan publiſhed a tract under the title of *Gigantomachie*, in which he maintains, that Habicot, in his Gigantoſteologie, had given falſe meaſures of the body and bones of the pretended giant Teutobochus; that Riolan meaſured the thigh-bone and the bone of the leg together with the aſtragalus joined to the calcaneum; that they exceeded not 6½ feet, even including the os pubis; and, of courſe, that the length of the giant could be only 13 feet, inſtead of 25. He then gives his reaſons for denying theſe bones to be human; and concludes, that the bones exhibited by Habicot belong not to man, but to the elephant.

A year after the publication of Habicot's Gigantoſteologie and Riolan's Gigantomachie, a pamphlet appeared under the title of *the Impoſture, concerning ſuppoſed human bones falſely attributed to King Teutobochus, diſcovered.* In this pamphlet, the bones are denied to be human, and ſuppoſed to have been engendered by ſome virtue in the earth. Another pamphlet was publiſhed without a name, in which it is ſaid, that, among theſe bones, ſome were human and others not.

In 1618, Riolan publiſhed his *Gigantologie*, in which he maintains, that the bones in queſtion were not only not human, but that men, in general, were never larger than they are at preſent.

In the ſame year, Habicot replied to Riolan: He ſays, that he preſented his Gigantoſteologie to Louis XIII.; that, about the end of July in the year 1613, the bones mentioned in this work were expoſed to the eye of the public; and that they are real human bones. He quotes a number of examples from ancient and modern authors, to prove that men of immenſe ſtature have exiſted. He perſiſts in maintaining, that the calcaneum, tibia, and femur of the giant Teutobochus, when joined to each other, were more than 11 feet in length.

He next gives letters written to him at the time theſe bones were diſcovered, and which ſeem to confirm the reality both of the tomb and of the bones of the giant Teutobochus. From a letter written by Seignior de Langon, dated St Marcellin, in Dauphiny, and another by the Sieur Maſurier, a ſurgeon at Beaurepaire, it appears, that ſilver coins were found along with the bones. The firſt letter contains the following paſſage: 'As his Majeſty,' ſays Seignior de Langon, 'is deſirous of having the remaining 'bones of King Teutobochus, and the ſilver coins 'found in the tomb, I declare, that your adverſaries 'are ill informed, and that, if they knew the matter more perfectly, they would not entertain 'any doubts that theſe bones really belong to the 'human ſpecies. The phyſicians of Montpellier 'came here, and would have given any money 'to purchaſe the bones. M. le Maréchal de 'Leſdiguieres made them be carried to Grenoble; and the phyſicians and ſurgeons of that 'place recogniſed them to be human bones. 'This fact, of courſe, can only be denied by 'perſons who are ignorant of the real circum'ſtances.'

In this diſpute, neither Riolan nor Habicot, the one a phyſician and the other a ſurgeon, have had ſenſe enough to give an exact deſcription of the bones in queſtion. Both of them, actuated by paſſion and a party-ſpirit, have written in a ſtyle which deſtroys all confidence in their aſſertions. Hence it is extremely difficult to aſcertain the ſpecies to which theſe bones really belonged. But, if they were found in a brick tomb, with a ſtone cover, upon which the words *Teutobochus Rex* were inſcribed; if coins were found in this tomb; if it contained but a ſingle ſkeleton of 24 or 25 feet in length; and, if Seignior Langon's letter relates nothing but truth, the general fact, *i. e.* the exiſtence of a giant of 24 feet high, unleſs we ſhould ſuppoſe a very extraordinary concourſe of falſehoods, could not admit of a doubt. But the fact is by no means proved, in a manner ſo explicit as not to leave room for much heſitation. It is true, that ſeveral authors, otherwiſe worthy of credit, have mentioned giants as large, and even larger. Pliny relates *, that, by an earthquake in Crete, a mountain was ſplit, and diſcovered a human body of 16 cubits long, which ſome aſcribed to that of Otus, and others to that of Orion. 16 cubits are equal to 24 feet, which is the ſame length with the ſkeleton of King Teutobochus.

In a Memoir of M. le Cat, an Academician of Rouen, we have an enumeration of ſeveral

giants

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* Lib. 7. cap. 16.

giants of enormous magnitude, namely, two, whoſe ſkeletons were found near Athens, of which one was 36 and the other 34 feet high; another of 30 feet was found in Sicily near Palermo, in the year 1548; another of 33 feet was likewiſe found in Sicily in the year 1550; and another was alſo found in Sicily, near Mazarino, which was thirty feet long.

Theſe teſtimonies notwithſtanding, it is difficult to believe that men of 30 or 36 feet high ever exiſted: It is perhaps too much to believe in the exiſtence of giants of 24 feet high. However, evidences multiply, become more poſitive, and gradually increaſe, in proportion as the dimenſions decreaſe. M. le Cat relates, that, in the year 1705, there was found, near the banks of the river Morderi, at the foot of Mount Cruſſol, the ſkeleton of a giant which meaſured 22½ feet; and that the Dominicans of Valencia have part of the tibia with the joint of the knee.

Platerus, a celebrated phyſician, aſſerts, that he ſaw at Lucerne the ſkeleton of a man, which was 19 feet in length.

The giant Ferragus, ſlain by Rolland, nephew to Charlemagne, was 18 feet high.

In the ſepulchral caverns of the iſland of Teneriff, a ſkeleton was found, which meaſured 15 feet, and in whoſe jaws were 80 teeth. Theſe three facts, as well as the preceding, are related

ted in M. le Cat's eſſay concerning giants. He mentions another ſkeleton found in a ditch near the convent of the Dominicans at Rouen, the ſkull of which held a buſhel of corn, and the bone of the leg was 4 feet long: The whole body, of courſe, muſt have been from 17 to 18 feet in length. Upon the tomb of this giant, the following inſcription was engraved: *Here lies the noble and puiſſant Seigniur le Chevalier Ricon de Valmont, together with his bones.*

In the Journal Littéraire of Abbé Nazari, we are told, that, in High Calabria, in the month of July 1665, there was dug out of the gardens of Signior de Tiviolo, a ſkeleton of 18 Roman feet long; that the head was 2½ feet; that each grinder weighed about an ounce and a third, and the other teeth three quarters of an ounce; and that this ſkeleton was bedded in a maſs of bitumen.

Hector Boethius, in his hiſtory of Scotland, relates, that the bones of a man, ironically called *Little John*, are ſtill preſerved, who was ſuppoſed to have been 14 feet high.

In the Journal des Savans, *anno* 1692, there is a letter from P. Gentil, profeſſor of philoſophy at Angers, in which he ſays, that, having been informed of a gigantic body diſcovered nine leagues from the town of Laſſé, he went to the ſpot to ſatisfy himſelf concerning the truth of the fact. He learned from the curate of the place, that, in digging his garden, a ſepulchre was diſcovered which contained a body of 17 feet 2 inches long. There was no ſkin on the body. This body had others between its arms and legs, which might have been the perſon's children. In the ſame place, there were diſcovered fourteen or fifteen other ſepulchres, ſome of them 10 feet, others 12, and others 14 feet long, which contained bodies of the ſame dimenſions. The ſepulchre of this giant continued expoſed to the air more than a year; but, as it attracted too many viſitors to the Curate, he again covered it with earth, and planted three trees in the place. Theſe ſepulchres were conſtructed with a ſtone which reſembled chalk.

Thomas Molineux ſaw, in a cabinet at Leyden, a prodigious human frontal bone. From its junction with the noſe to the ſagittal ſuture, it was $9\frac{1}{12}$ inches; its length was $12\frac{2}{10}$ inches, and its thickneſs half an inch, *i. e.* in every dimenſion it was double that of an ordinary frontal bone. Hence the perſon to whom this gigantic bone belonged muſt have been twice the common ſize of a man, or at leaſt 11 feet high. This bone was unqueſtionably human; and it ſeemed not to have acquired this uncommon magnitude by the effects of any diſeaſe; for its thickneſs was exactly proportioned to its other dimenſions, which never happens in diſeaſed bones *.

M.

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* Phil. Tranſ. No 168. art. 2.

M. Klein tells us, that he ſaw, in the cabinet of M. Witreu at Amſterdam, a frontal bone; from the dimenſions of which it appeared, that the perſon to whom it appertained muſt have been 13 feet 4 inches high, *i. e.* about $12\frac{1}{2}$ French feet *.

After all theſe facts, I ſhall leave my readers in the ſame embarraſſment as myſelf, with regard to the real exiſtence of giants of 24 feet in length. I cannot perſuade myſelf, that at any time, or by any circumſtances whatever, the human body could be elevated to ſuch immoderate dimenſions. But, at the ſame time, it is unqueſtionable, that giants of 10, 12, and perhaps even of 15 feet high, have exiſted; and it is almoſt certain, that, in the primaeval ages of Nature, not only gigantic individuals, but even permanent and ſucceſſive races of giants, were produced, of which that of the Patagonians is the only remaining example.

TO prove that ſome of the fiſhes and plants found in coal and ſlate belong to ſpecies which no longer exiſt, the Count de Buffon produces the following facts and obſervations.

With regard to this ſubject, we ſhall remark, with M. Lehman †, that there are no impreſſions

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* Phil. Tranſ. No 456. art. 3.

† Tom. 3. p. 407.

ſions of plants in ſlate, except when it accompanies pit-coal; and that, on the contrary, impreſſions of fiſhes are ſeldom found but in coppery ſlates.

It has likewiſe been remarked, that, in the diſtrict of Mansfield, the beds of ſlate which contain petrified fiſhes, are covered with a ſtratum of ſtones called *ſtinking ſtones.* This ſtratum is a ſpecies of gray ſlate, which has derived its origin from ſtagnant water, where the fiſhes had corrupted before they were petrified*.

M. Hoffman, when treating of ſlates, ſays, that the petrified fiſhes found in theſe ſtones have not only been living creatures, but that the ſtrata of ſlate have originated from muddy water, which, after fermenting and petrifying, ſubſided in thin laminae or beds.

'In the ſlate of Angers,' ſays M. Guettard, 'there are ſometimes impreſſions of plants and 'fiſhes, which merit the greater attention, be'cauſe the impreſſions of the plants repreſent 'marine *fuci*, or ſea-wreck, and thoſe of the 'fiſhes repreſent different ſpecies of the cruſta'ceous tribes, the impreſſions of which are 'more rare than thoſe of ſcaly fiſhes, or ſhells. 'He adds, that, after conſulting ſeveral authors 'who treat of fiſhes and cruſtaceous animals, 'he could not diſcover any of them that re'ſembled

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* Leeberoth, Journal Oeconomique, Juillet 1752.

'ſembled the impreſſions in queſtion, except 'the ſea-louſe, which has ſome reſemblance to 'them; but it has thirteen rings, and the im'preſſions on the ſlates have only ſeven or eight: 'The impreſſions of theſe fiſhes are generally 'interſperſed with a whitiſh pyritous ſubſtance. 'It is remarkable, that, in the ſlates of Angers, 'as well as in thoſe of other countries, the im'preſſions of fiſhes are frequent, and thoſe of 'ſhells are exceedingly rare, whilſt the latter are 'very common in lime-ſtone *.'

Many proofs might be given that all pit-coal is compoſed of the ſpoils of vegetables, mixed with bitumen and ſulphur, or rather with the vitriolic acid, which is perceived when the coal is burning. We often find a great quantity of vegetables in the upper ſtrata of coal; and, in proportion as we deſcend, we ſee traces of the decompoſition of the ſame vegetables. There are ſpecies of coal which are not foſſil wood: That found at Sainte-Agnés, near Lons-le-Saunier, has a perfect reſemblance to logs or trunks of fir, in which we diſtinctly perceive the marks of each year's growth, as well as the pith. Theſe trunks differ only from common fir by being ſomewhat oval, and by their rings being concentric ellipſes. They exceed not a foot in circumference, and their bark is very thick and full of furrows, like that of old firs. But the bark

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* Mem. de l'Acad. des Sciences, année 1757, p. 52.

bark of common firs, of the ſame ſize, is always ſmooth.

‘ I found,’ M. de Genſanne remarks, ‘ ſeveral veins of this kind of coal in the dioceſe ‘ of Montpellier: Here the trunks are very ‘ large; their texture reſembles that of cheſnut-‘ trees from three to four feet in circumference. ‘ Theſe foſſils, when burning, have only a ſlight ‘ odour of aſphaltis. Their flame and embers ‘ reſemble thoſe of wood. They are found ‘ near the ſurface of the earth, and commonly ‘ indicate the exiſtence of real pit-coal at great-‘ er depths *.’

Theſe ligneous coals ought to be regarded as wood depoſited in a bituminous earth, from which they derive their foſſil quality. They are found only in earths of this kind, and always near the ſurface. They ſometimes form the ſtratum immediately above the ſeams of real coal. Some of them, which have been impregnated with a ſmall quantity only of bitumen, preſerve the ſhades and colour of wood. ‘ I found ‘ this ſpecies,’ ſays M. de Genſanne, ‘ at Cazarets, ‘ near Saint-Jean-de-Culcul, four leagues from ‘ Montpellier. But, when broken, this foſſil ‘ commonly preſents a ſmooth ſurface, perfectly ‘ ſimilar to that of jet. In the ſame canton, ‘ near Aſeras, there is foſſil wood changed into

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* Hiſt. Nat. du Languedoc, par M. de Genſanne, tom. 1. p. 20.

‘ a white ferruginous pyrites. The mineral ‘ matter occupies the heart of the wood; and ‘ we diſtinctly perceive the woody ſubſtance ‘ furrowed and partly diſſolved by the mineral ‘ acid *.’

After ſuch proofs, related by M. de Genſanne himſelf, who is otherwiſe a good mineralogiſt, I acknowledge, that I was ſurpriſed to ſee him aſcribe the origin of coal to clay more or leſs impregnated with bitumen. This notion is not only refuted by his own facts, but we ſhall be convinced by thoſe I am about to relate, that we ought to attribute the origin of every ſpecies of coal to the ſpoils of vegetables mixed with bitumen.

I agree with M. de Genſanne, that neither this foſſil wood, nor turf, can be conſidered as coal completely formed. That found near Lons le-Saunier has been recently examined by the Preſident de Ruffey, a learned Academician of Dijon: He remarks, that this foſſil wood makes a near approach to the nature of pit-coal; and that it is found within two or three feet of the ſurface through an extent of two leagues; that it is from three to four feet thick; that we eaſily diſtinguiſh the ſpecies of wood to be oaks, horn-beams, and trembling poplars; that this wood is ſometimes in the form of bundles or faggots; that the bark of the logs is well preſerved;

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* Hiſt. Nat. du Languedoc, tom. 1. p. 54.

preſerved; that the annual circles, the cuts made by the axes, and, at different diſtances, collections of chips, are plainly diſtinguiſhable; that this wood converted into coal is excellent for ſoldering iron; that, when burning, it diffuſes a fetid odour; and that allum has been extracted from it *.

'Near the village called *Beichlitz*, about a 'league from the town of Halle, two ſtrata, 'compoſed of a bituminous earth and foſſil 'wood, (of which there are ſeveral mines in the 'country of Heſſe,) were diſcovered. It is ſimi'lar to that found in the village of Sainte-Ag'nés in Franche-comté, two leagues from 'Lons-le-Saunier. This mine is in the territo'ry of Saxe. The firſt ſtratum lies at the depth 'of three fathoms and a half, and is from eight 'to nine feet thick. To arrive at it, we cut 'through a white ſand, then a whitiſh gray clay, 'which is three feet thick: Still deeper, we 'meet with a conſiderable thickneſs both of ſand 'and clay, which cover the ſecond ſtratum. 'This ſtratum is only from three and a half to 'four feet thick. We ſounded deeper, but 'found no other ſtrata of that kind.

'Theſe ſtrata are horizontal; but they ſink 'or riſe nearly in the ſame manner as common 'ſtrata. They conſiſt of a brown bituminous 'earth, which is friable when dry, and reſem'bles

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* Mem. de l'Acad. de Dijon, tom. 1. p. 47.

‘ bles corrupted wood. Pieces of wood of all ‘ ſizes are found, which, when taken from the ‘ mine, where they are ſoft, muſt be cut with an ‘ ax. This wood, when dry, breaks eaſily. ‘ When broke, it ſhines like bitumen; but ‘ we diſtinctly perceive in it the whole organi‘ zation of wood. It is leſs abundant than the ‘ bituminous earth, and the workmen lay it ‘ aſide for their own uſe.

‘ A buſhel or two quintals of bituminous ‘ earth ſells for eighteen or twenty French ‘ ſous. In theſe ſtrata there are pyrites; they ‘ are of a vitriolic nature; when expoſed to the ‘ air they effloreſce and turn white: But the bi‘ tuminous matter is of little value, as it gives ‘ but a feeble heat *.’

Hence this ſpecies of foſſil wood, found ſo near the ſurface of the earth, muſt be a much more recent production than common pit-coal, which is almoſt conſtantly ſunk very deep. But this idea does not preclude the ancient coal from being formed of the ſpoils of vegetables; ſince, in the deepeſt coal-mines, we recogniſe woody ſubſtances, and ſeveral characters which belong to vegetables only. Beſides, there are ſome examples of foſſil wood found in large maſſes, and in extenſive beds, under ſtrata of free-ſtone and calcarious rocks. Hence there is no other difference

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* Voyages Metalurgiques de M. Jars, p. 320.

ference between real pit-coal and theſe charred woods, but what ariſes from the degree of decompoſition, and from a greater or ſmaller impregnation with bitumen. The baſis of their ſubſtance is the ſame; and both derive their origin from the ſpoils of vegetables.

M. le Monnier, one of the King's phyſicians, and a learned botaniſt, found, in the ſchiſt, or falſe ſlate, which traverſes a large field of pit-coal in Auvergne, the impreſſions of ſeveral ferns, almoſt the whole of which were unknown to him: He only thought, that he could diſtinguiſh the impreſſion of the leaves of the oſmund-royal, of which he ſaw but one example in all Auvergne *.

It were to be wiſhed that botaniſts would examine more accurately the impreſſions of plants found in pit-coal and in ſlate. The impreſſions of plants, as well as thoſe of cruſtaceous animals, ſhells, and fiſhes, found in theſe minerals, ſhould be drawn and engraved; for all this labour is neceſſary to enable us to determine the actual or the paſt exiſtence of theſe ſpecies, or even their relative antiquity. At preſent, we are ſatisfied, that moſt of them are unknown, and that, in thoſe which have been referred to known ſpecies, the differences are always ſo great as to create heſitation.

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* Obſervations de Hiſt. Nat. par M. le Monnier, p. 193.

The Count de Buffon remarks, That the motion of the waters from eaſt to weſt has diminiſhed the ſurface of the earth on the weſt ſide; and that, in every continent of the globe, the declivity is more rapid on the weſt than on the eaſt coaſts. This is evident in the continent of America, the declivities of which are extremely rapid and abrupt toward the weſtern ſeas; but, towards the eaſtern coaſts, the lands ſtretch by a gentle declivity, and generally terminate in large plains. In Europe, the line that forms the ſummit of Great Britain, which runs from north to ſouth, is much nearer the weſtern than the eaſtern ocean: For the ſame reaſon, the ſeas to the weſt of Britain and Ireland are much deeper than the ſea which ſeparates Britain and Holland. The ridge of Norway is much nearer the ocean than the Baltic ſea. The mountains which form the general ſummit of Europe are much higher toward the weſt than the eaſt; and, if we take a part of this ſummit, from Switzerland to Siberia, it is much nearer the Baltic and White Seas, than the Black Sea and the Caſpian. The Alps and Apennines are nearer the Mediterranean than the Adriatic ſea. The chain of mountains which runs from Tirol to Dalmatia, and as far as the Morea, in a manner ſkirts the Adriatic ſea; but the oppoſite coaſts are much lower In Aſia, if we follow the chain which extends from the Dardanelles to the ſtrait of Babelmandel, we ſhall find that the ſummits of Mount Taurus, of Libanus, and of all Arabia, ſkirt the Mediterranean and the Red Seas; and that, to the eaſt, there are vaſt territories where the long courſed rivers run, and at laſt empty themſelves in the Perſic Gulf. The ſummit of the famous mountains of Gate approaches nearer to the weſtern than the eaſtern ſeas. The ridge which extends from the weſt frontiers of China to the point of Mallacca, is nearer the weſt than the eaſt ſea. In Africa, the chain of Mount Atlas ſends rivers to the ſea of the Canaries, whoſe courſes are much ſhorter than thoſe which run into the interior parts of the Continent, and, after traverſing vaſt tracts of country, loſe themſelves in lakes or great marſhes. The high mountains to the weſt of Cape Verd, and through all Guiney, after turning round Congo, join the mountains of the Moon, and ſtretch as far as the Cape of Good Hope, occupy pretty uniformly the middle of Africa: We will perceive, however, on examining the ſea to the eaſt and weſt, that the ſea on the eaſt is not deep, and is interſperſed with a great number of iſlands; whilſt, to the weſt, it is deeper, and has but few iſlands; ſo that the deepeſt places of the weſtern ſea are much nearer this chain of mountains than the deepeſt places of the eaſtern or Indian ſeas.

Hence we ſee that, in general, all the points of partition in the great continents are always nearer the weſt than the eaſt ſeas; that the plains of theſe continents are always lengthened toward the eaſt, and ſhortened toward the weſt; that the ſeas on the weſt coaſts are deeper, and have fewer iſlands than thoſe on the eaſt; and that, in all theſe ſeas, the weſt coaſts of the iſlands are always higher, and the ſeas which waſh them deeper, than thoſe on the eaſt.

We are next told, that there are animals, and even men, ſo brutiſh, that they rather languiſh in the ungrateful ſoil where they were brought forth, than take the trouble of removing to a more comfortable ſituation. Of this, ſays the Count de Buffon, I can give a ſtriking example: The Maillés, a ſmall ſavage nation in Guiana, near the mouth of the river Ouaſſa, have no other habitation than trees, upon which they dwell during the whole year, becauſe their country is always more or leſs covered with water. They never deſcend from theſe trees, except when they go in canoes in queſt of ſubſiſtence. This is a ſingular example of a ſtupid attachment to a native country; for theſe ſavages, in order to procure habitations on land, have only to remove a few leagues from thoſe drowned ſavannahs which gave them birth, and which they obſtinately refuſe to abandon. This fact is mentioned by ſome voyagers *, and has been confirmed to me, by ſeveral witneſſes, who have lately ſeen this ſmall nation, which conſiſts of three or four hundred ſavages. They keep themſelves above the water by means of the trees. There they remain the whole year. During the eight or nine rainy months, their country is a large ſheet of water; and, during the four ſummer months, their ſoil conſiſts of a dirty mud, upon which a cruſt of five or ſix inches thick is formed. This cruſt is rather compoſed of herbage than of earth, under which is a conſiderable depth of ſtagnant and ſtinking water.

The Caſpian Sea, the Count de Buffon remarks, was formerly much larger than it is at preſent.——'In traverſing,' ſays M. Pallas, 'the 'immenſe deſerts which lie between the Wolga, 'the Jaïk, the Caſpian Sea, and the Don, I ob'ſerved, that theſe *ſteppes* or ſandy deſerts, are 'every way ſurrounded with an elevated border, 'which embraces a great part of the beds of the 'Jaïk, Wolga, and Don; and that theſe deep 'rivers, before they penetrated this incloſing 'belt, were full of iſlands and ſhoals, till they

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* The Maillés, one of the ſavage nations of Guiana, dwell along the coaſt. Their country is often covered with water. They, therefore, build their cabbins upon trees, to the feet of which they faſten their canoes, in which they ſail in queſt of ſubſiſtence; *Voyage de Deſmarchais, tom. 4. p. 352.*

‘ began to fall into the deſerts where the great ‘ river Kuman loſes itſelf in the ſands. From ‘ theſe obſervations I conclude, that *the Caſpian* ‘ *Sea has formerly covered all theſe deſerts*; that ‘ it anciently had no other margins than thoſe ‘ elevated belts which every where ſurround the ‘ deſerts; and that it has communicated, by ‘ means of the Don, with the Black Sea, even ‘ ſuppoſing this ſea, as well as that of Azoff, had ‘ never made a part of it *.’

M. Pallas is unqueſtionably one of our moſt learned naturaliſts; and it is with the greateſt pleaſure that I ſee him here entirely of my opinion with regard to the ancient extent of the Caſpian, and the probability that it formerly communicated with the Black Sea.

There have been greater and more frequent revolutions in the Indian ocean than in any other part of the globe. But, ſays the Count de Buffon, tradition has only handed down to us the ſubmerſion of Taprobana.——The moſt ancient tradition we have of the ſinking of countries in the ſouth is that of the loſs of Taprobana; of which the Maldivas and Laquedivas are ſuppoſed to have been formerly a part. Theſe iſlands, as well as the rocks and banks which prevail from Madagaſcar to the point of India, ſeem

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* Journal Hiſtorique et politique, mois de Novembre 1773; Art. Peterſbourg.

ſeem to indicate the ſummits of countries that united Africa to Aſia; for almoſt all of theſe iſlands have, on the north ſide, lands and banks which ſtretch very far under the waters.

It likewiſe appears, that the iſlands of Madagaſcar and Ceylon were formerly united to the adjacent continents. Moſt of theſe ſeparations and revolutions in the ſouthern ſeas have been produced by the ſinking of caverns, by earthquakes, and by exploſions of ſubterraneous fires. But lands have alſo been carried off by the ſlow and gradual movement of the waters from eaſt to weſt. The places where theſe effects are moſt apparent are the regions of Japan, of China, and of all the eaſtern parts of Aſia. The ſeas ſituated to the weſt of China and Japan ſeem to be accidental productions, and perhaps more recent than our Mediterranean.

The iſlands of Sunda, the Moluccas, and the Philippines, preſent nothing but countries which have been overturned; and they are ſtill full of volcano's. There are many volcano's in the Japaneſe iſlands; and Japan is reputed to be more ſubject to earthquakes than any other part of the globe: It alſo gives riſe to a number of hot fountains. The greater part of the iſlands in the Indian ocean preſent only peaks or ſummits of detached mountains, which continually vomit fire. The iſles of France and Bourbon appear to be two of theſe ſummits: They are almoſt entirely covered with matters rejected by volcano's. Theſe two iſlands, when firſt diſcovered, were uninhabited.

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In Guiana, our author remarks, the rivers are ſo near each other, and at the ſame time ſo ſwelled and rapid during the rainy ſeaſon, that they carry down immenſe quantities of mud, and depoſit them on all the low grounds and on the bottom of the ſea. The coaſts of French Guiana are ſo low, that they may rather be regarded as beaches totally covered with mud, and having an almoſt imperceptible declivity. This mud extends to a great diſtance at the bottom of the ſea. Large veſſels cannot approach the river Cayenne without ſtriking; and ſhips of war are obliged to remain two or three leagues from the land. This mud extends along the whole margin of the ſea from Cayenne to the river of the Amazones. In this great extent of mud there is no ſand, and berry-bearing alders are frequent all along the coaſt. But, ſeven or eight leagues above Cayenne, weſtward as far as the river Marony, we find ſome creeks, the bottoms of which conſiſt of ſand and rocks, which give riſe to breakers. The mud, however, covers the greater part of theſe rocks, as well as the beds of ſand; and it is thicker in proportion as it recedes from the margin of the ſea. Theſe ſmall rocks prevent not the ground from having a very gentle deſcent for ſeveral leagues on land. This part of Guiana, which, to the north-weſt of Cayenne, is more elevated than the lands to the ſouth-eaſt. Of this fact we have good evidence; for all along the borders of the ſea, we find large drowned ſavannahs, moſt of which are dry in the north-weſt, whilſt they are totally covered with ſea-water in the ſouth-eaſt parts. Beſide theſe lands actually drowned by the ſea, there are others more diſtant, which have likewiſe been formerly drowned. In ſome places we alſo find ſavannahs of freſh water; but they produce no alders, but many palm-trees. On all theſe low coaſts, not a ſtone is to be ſeen. The tide riſes ſeven or eight feet, though it is oppoſed by the currents; for they are all directed toward the Antilles. When the waters of the rivers are low, the tide is very perceptible, as high up the rivers as forty and even fifty leagues. But, during the rainy ſeaſon, when the rivers are ſwelled, the tide is ſcarcely perceptible at the diſtance of a league or two, ſo great is the rapidity of the waters; and their impetuoſity is greateſt during the reflux.

Upon the ſandy bottoms of theſe creeks, the ſea-turtles depoſit their eggs; and they never frequent the muddy places; ſo that, from Cayenne to the river of the Amazones, there are no turtles; and the people go to fiſh them from the river Courou to the Marony. The mud appears to gain ground daily on the ſand; and, in the progreſs of time, the north-weſt coaſt of Cayenne will be covered with it as well as the ſouth-eaſt; for the turtles, who will depoſit their eggs in ſand only, gradually retire from the river Courou; and, for ſome years paſt, the fiſhers are obliged to ſearch for them near the river Marony, the ſands of which are not yet covered.

Beyond the ſavannahs, ſome of which are dry and others drowned, there is a chain of hills that are all covered with a great depth of earth, and every where planted with foreſts. Theſe hills are generally from 350 to 400 feet high. But, about ten or twelve leagues farther up the country, they are perhaps double this height. Moſt of theſe mountains are evidently extinguiſhed volcano's. At the top of one of them, called *la Gabrielle*, there is a ſmall lake, in which are a number of alligators, whoſe ſpecies ſeems to have been preſerved from the time that the ſea covered this hill.

Beyond Mount Gabrielle, we find only ſmall valleys, little hills, and volcanic matters, not in large maſſes, but in ſmall blocks. The moſt common ſtone, blocks of which are carried down by the waters as far as Cayenne, is that called *beetle-ſtone*. It is not a ſtone, but the lava of a volcano. It has received the name of *beetle-*

ſtone, becauſe it is full of holes, which theſe inſects inhabit.

Of the Glaciers.

In the higheſt regions of the Alps, the waters which proceed from the annual meltings of the ſnow, freeze in every direction, and on all the points of the mountains from their baſes to their ſummits, and eſpecially in the valleys, and on the declivities of thoſe that are collected together in groups: In this manner, the waters have formed in theſe valleys ſome mountains which have rocks for their nucleus, and others that conſiſt entirely of ice: Theſe mountains are ſix, ſeven, and even eight leagues long by one in breadth, and often from a thouſand, to twelve hundred fathoms high. Theſe enormous maſſes of ice are continually extending farther along the valleys; for though, in warm and rainy ſeaſons, their progreſs is not only ſtopped, but their ſize diminiſhed, the magnitude of the glaciers is perpetually augmenting.

Under the equator, the point of congelation, in detached mountains, is fixed at the height of 2440 fathoms. But this is no rule for groups of mountains which are frozen from their ſummits to their baſe, and never thaw. In the Alps, the point of congelation in detached mountains is aſcertained to be at the height of 1500 fathoms, and all below this point thaws completely. But thoſe which are grouped together freeze at a ſmaller height, and thaw from their top to their baſe; which ſhows how much the degree of cold is augmented by immenſe maſſes of congealed matter confined within a narrow compaſs.

The whole frozen mountains of Switzerland, when taken together, occupy an extent of 66 leagues from eaſt to weſt, meaſured in a ſtraight line from the weſtern borders of the canton of Vallis towards Savoy, to the eaſtern borders of the canton of Bendner towards Tirol. They form an interrupted chain, ſeveral arms of which extend, from north to ſouth, about 36 leagues. The great Gothard, the Fourk, and the Grimſel, are the higheſt mountains in this quarter: They occupy the center of thoſe chains which divide Switzerland into two parts. They are perpetually covered with ſnow and ice; from which circumſtance they have received the general denomination of *Glaciers.*

The glaciers are divided into frozen mountains, valleys of ice, fields of ice or frozen ſeas, and *gletchers*, or heaps of icy flakes or plates.

The frozen mountains are thoſe immenſe maſſes of rocks which reach the clouds, and are perpetually covered with ice and ſnow.

The valleys of ice are thoſe depreſſions between the mountains which are much more elevated than the inhabited valleys. They are always filled with ſnow, which accumulates, and forms maſſes of ice ſeveral leagues in length. Theſe maſſes join the high mountains.

The fields of ice, or frozen ſeas, which lie along the mountains, have a gentle declivity. They cannot be called valleys, becauſe they are not ſufficiently depreſſed. They are covered with a great thickneſs of ſnow. Theſe fields receive water from the melting of the ſnow, which deſcends from the mountains, and afterwards freeze. The ſurface of theſe fields alternately melts and freezes; and the whole are covered with thick beds of ſnow and ice.

The gletchers are heaps of flakes or plates of ice formed by the ſnows, and precipitated from the mountains. Theſe ſnows freeze again, and are interwoven in various manners: This circumſtance has given riſe to the diviſion of gletchers into mounts, mantlings, and walls of ice.

The mounts of ice riſe between the ſummits of the high mountains: They themſelves form mountains; but they contain no rocks. They are compoſed entirely of ice, and are ſometimes ſeveral leagues in length, one league broad, and half a league thick.

The mantlings are formed in the ſuperior valleys, and upon the ſides of the mountains, which are covered with ice, having folds reſembling drapery: They ſend their ſuperfluous waters into the lower valleys.

The walls of ice are rugged mantlings which terminate the flat valleys, and appear, at a diſtance, like troubled ſeas, whoſe waves have been ſuddenly arreſted and frozen. Theſe walls conſiſt not of irregular points: They often form columns, pyramids, and enormous towers compoſed of ſeveral ſides. Theſe towers are ſometimes hexagonal, and of a blue or greeniſh colour.

On the ſides, and at the foot of the mountains, maſſes of ſnow are formed, which are afterwards moiſtened with the water from the melted ſnows, and then covered with freſh accumulations. We likewiſe ſee plates of ice collected in heaps, which belong neither to the frozen valleys nor the mountains of ice. Their poſition is either horizontal or inclined. Theſe detached heaps are called *beds* or *ſtrata* of ice.

Several of theſe mountains of ice are undermined by the interior heat of the earth, which gives riſe to currents of water that melts their inferior ſurfaces. They then, by their own weight, ſink inſenſibly, and their height is reſtored by the waters, ſnow, and ice, which again ſucceſſively cover them. Theſe ſinkings often produce horrible craſhings. The crevices which open in the ice form precipices which are both numerous and full of danger. Theſe abyſſes are the more treacherous and baneful, becauſe they are generally covered with ſnow. Travellers, and hunters who chaſe the fallow-deer, the chamois goat, &c. or thoſe who ſearch for cryſtals, are often ſwallowed up by theſe gulfs, and again thrown upon the ſurface by the waters which run at their bottoms.

Gentle rain quickly diſſolves ſnows: But all the water which proceeds from them falls not into theſe gulfs. A great part of it freezes on the ſurface of the ice and augments its volume.

The warm ſouth winds, which generally prevail in the month of May, are the moſt powerful agents in deſtroying the ſnows and ice. Their melting is announced by the craſhing of the frozen lakes, and the dreadful noiſe produced by the ſhock of ſtones and ice, which in horrible confuſion roll down from the tops of the mountains, and by torrents of water that fall from the rocks of more than 1200 feet high.

The heat of the ſun has little effect upon the ſnow and ice. Experience has proved, that ice which has exiſted a long time under an enormous weight, and in accumulated degrees of cold, is ſo denſe and ſo completely deprived of air, that, when ſmall pieces of it are expoſed to the greateſt heat of the ſun, during a whole day, they ſcarcely melt.

Though the glaciers melt partially every ſummer, though the winds and the heat of certain years deſtroy the accumulation of ſeveral preceding years; yet it is certain, that theſe *glaciers conſtantly augment in all their dimenſions.* This fact is aſcertained by the annals of the country, by authentic deeds, and by invariable tradition. Independent of theſe authorities, and of daily obſervation, the progreſſive increaſe of the glaciers is proved by *foreſts of trees which have been abſorbed by the ice, ſome of whoſe tops ſtill appear above the ſurface of the glaciers*: Theſe, as well as *the tops of ſteeples belonging to a village* that had been buried under the ſnows, and which are ſtill viſible after uncommon meltings, are irrefragable evidences of the gradual progreſs of the glaciers. This progreſſion can proceed from no other cauſe than an augmentation in the degree of cold, which increaſes in proportion to the maſſes of accumulated ice. It is likewiſe certain, that, in the glaciers of Switzerland, the cold is at preſent more intenſe, though it continues ſhorter, than in Iceland, the glaciers of which, as well as thoſe of Norway, have a great relation to thoſe of Switzerland.

The ſubſtance of the frozen mountains of Switzerland is ſimilar to that of all other high mountains. The nucleus is a vitreous rock which reaches to their ſummit. The parts below, which had been covered with the ocean, are compoſed of calcarious ſtone, as well as the whole ſubſtance of the mountains of an inferior order, which are diſpoſed in groups at the foot of the primitive glacier mountains. Laſtly, theſe calcarious maſſes have ſlate, produced by the ſediments of the waters, for their baſis.

The vitreous maſſes are pure rock, granite, and quartz. Their fiſſures are filled with metals, ſemi-metals, mineral ſubſtances, and cryſtals.

The calcarious maſſes are lime-ſtone, marbles of every ſpecies, chalk, gypſum, ſpar, alabaſter, &c.

The ſlaty maſſes conſiſt of ſlates of various qualities and colours, which contain plants and fiſhes, and are often ſituated at conſiderable heights. Their ſtrata are not always horizontal. They are often inclined, ſometimes ſinuated, and in particular places perpendicular.

We cannot entertain a doubt concerning the ancient abode of the ſea upon the glacier mountains. The immenſe quantity of ſhells, as well as the ſlate and other ſimilar ſtones, found in theſe mountains, fully aſcertain this point. Theſe ſhells are either diſtributed in tribes, or different ſpecies are blended together, and they are found at very great heights.

It is probable, that, at a very remote period, the glaciers had not been formed on theſe mountains, not even when the ocean abandoned them ; though it appears by their great diſtance from the ſea, which is near a hundred leagues, and by their exceſſive height, that they were the firſt that aroſe above the water in the Continent of Europe. They have likewiſe had their volcano's. Mount Myſſenberg, in the canton of Schwitz, ſeems to have been the laſt volcano that was extinguiſhed. The two principal ſummits, which are very high and detached, terminate in cones, like all the mouths of volcano's; and we ſtill ſee the crater of one of theſe cones, which is very deep.

M. Bourrit, who had the courage to make a number of expeditions in the glaciers of Savoy, remarks, 'That the increaſe of all the glaciers in 'the Alps is unqueſtionable; that the quantity 'of ſnow that falls during the winters far ſurpaſ-'ſes that which melts in the ſummers; that the 'ſame cauſe not only ſubſiſts, but the maſſes of 'ſnow already formed muſt always augment, 'becauſe this effect is a neceſſary reſult of that 'cauſe. Hence the glaciers muſt always continue 'to have a progreſſive increaſe *.'

The ſame indefatigable obſerver, when treating of the *glatchers* or glaciers with prominent points, ſays, 'that they appear to augment 'daily; that the ground they now occupy was 'ſome years ago a cultivated field; and that the 'ice ſtill continues to augment †.' He relates, that

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[*] Deſcript. des glaciers de Savoie, par M. Bourrit, p. 111, 112.

[†] Deſcript. des aſpects du Mont Blanc, par le même, p. 8.

'that the growth of the ice is evident, not on-
'ly in this place, but in ſeveral others; that the
'inhabitants remembered a former communi-
'cation between Chamounis and Val-d'Aoſt,
'which is now totally ſhut up by the ice; that
'the ice, in general, muſt have firſt accumulated
'by ſtretching from ſummit to ſummit, and then
'from one valley to another; and that, in this
'manner, a communication has been formed
'between the ice of Mount Blanc and thoſe of
'the other mountains of Vallais and of Swit-
'zerland *. It appears,' ſays he, 'that all theſe
'mountainous countries were not anciently ſo
'much filled with ice and ſnow as they are at
'preſent . . . It is only a few centuries
'ſince various calamities have been occaſioned
'by the accumulation of ſnows and ice, in ſeve-
'ral valleys, and by the precipitation of moun-
'tains and rocks. It is only from theſe acci-
'dents, which are very frequent, and from the
'annual accumulations of the ice, that we are
'enabled to account for what hiſtory relates
'concerning the ancient inhabitants of this coun-
'try †.'

Of

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* Deſcript. des aſpects du Mont Blanc, par M. Bourrit, p. 13. et 14.

† Ibid. p. 62. et 63.

Of the North-Eaſt paſſage.

Notwithſtanding what has been advanced by the Ruſſians, it is extremely doubtful that they ever doubled the northern point of Aſia. M. Engel, who regards the north-weſt paſſage by Hudſon's and Baffin's bay, as impoſſible, appears, on the contrary, to be perſuaded, that a ſhorter and more certain paſſage will be found by the north-eaſt. To the feeble reaſons he gives in ſupport of this opinion, he adds a remark of M. Gmelin, who, when ſpeaking of the experiments made by the Ruſſians, in order to diſcover this north-eaſt paſſage, ſays, 'that 'the manner in which they proceeded in making theſe diſcoveries will aſtoniſh the whole 'world, after an authentic relation of them 'ſhall be made public, which depends ſolely 'on the pleaſure of the Empreſs.'——'There 'can be nothing aſtoniſhing,' ſays M. Engel, 'in this ſubject, except it be to learn that 'a paſſage, which was formerly regarded as impoſſible, is now found to be extremely practicable. This is the only fact,' he adds, 'which 'can ſurpriſe thoſe whom the Ruſſians have 'endeavoured to terrify by relations publiſhed 'for the purpoſe of repelling navigators from 'the attempt *,' &c.

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* Hiſt. Gen. des Voyages, tom. 19. p. 415.

I ſhall, in the firſt place, remark, that we ought to be well aſcertained with regard to facts, before we throw an imputation of this kind upon the Ruſſian empire. In the ſecond place, the remark ſeems to be ill founded; for the words employed by M. Gmelin may admit of an oppoſite interpretation from that given of them by M. Engel, namely, That we will be aſtoniſhed when we ſhall learn that no practicable paſſage exiſts by the north-eaſt. Independent of the general reaſons I have given, I am confirmed in this opinion by the following circumſtance: The Ruſſians themſelves, in their late experiments, uniformly aſcend by Kamptſchatka, and never deſcend by the point of Aſia. Captains Bering and Tſchirikow, in the year 1741, reconnoitered the coaſt of America as far as the 59th degree; but neither of them ſailed northward along the coaſts of Aſia. This fact is a ſufficient proof, that the paſſage is not ſo practicable as M. Engel ſuppoſes; or rather, that the Ruſſians are ſatisfied that it is not practicable; for, if otherwiſe, their navigators would have been ſent by this route, inſtead of making them take their departure from Kamptſchatka, in order to diſcover the weſt of America.

M. Muller, who was ſent by the Empreſs, along with M. Gmelin, to Siberia, is of a very different opinion from M. Engel. After comparing all the relations on this ſubject, M. Muller concludes

concludes by remarking, that there is only a very ſmall ſeparation between Aſia and America; and that this ſtrait contains ſeveral iſlands, which ſerve as common ſtations to the inhabitants of both continents. This opinion, I believe, is well founded; and, in ſupport of it, M. Muller has collected a great number of facts. In the ſubterraneous abodes of the inhabitants of the iſland of Karaga, we ſee beams made of large pines, which neither this iſland, nor the adjacent countries of Kamtſchatka, produce. The inhabitants ſay, that this wood is driven upon their coaſts by the eaſt wind. On the coaſts of Kamtſchatka, boards of ice are driven, for ſeveral days together, during the winter. At certain ſeaſons, flights of birds arrive, and, after ſtaying ſome months, return to the eaſt, from whence they came. Hence the continent oppoſite to that of Aſia, toward the north, deſcends as far as Kamtſchatka. This continent muſt be the weſt of America. M. Muller *, after giving an abridgement of five or ſix voyages attempted by the north ſea, with a view to double the north point of Aſia, concludes, that every circumſtance announces the impoſſibility of this navigation, which he proves by the following arguments. This navigation muſt be performed in ſummer: The diſtance from Archangel to the Oby, and from this

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* Hiſt. Gen. des Voyages, tom. 18. p. 484.

this river to Jeniſey, requires a whole ſeaſon. The paſſage by Waygait has coſt infinite labour to the Britiſh and Dutch. In going through this icy ſtrait, we meet with iſlands which block up the road; and the continent, which forms a cape between the rivers Piaſida and Chatanga, and advances beyond the 76th degree of latitude, is likewiſe bordered with a chain of iſlands, which ſcarcely leave a paſſage for navigation. If we want to remove from the coaſts, and to reach the open ſea toward the Pole, the almoſt immoveable mountains of ice found at Greenland and Spitzbergen, ſeem to indicate a continuity of ice as far as the Pole. If we want to go along the coaſts, *this navigation is more difficult now than it was a hundred years ago.* There the waters of the ocean are ſenſibly diminiſhed: We ſtill ſee, at a diſtance from the ſhoals along the Frozen Sea, wood that had been thrown upon the lands which formerly bounded the ocean. Theſe ſhoals have ſo little depth, that very flat boats can alone be uſed in them: ſuch boats are too weak to reſiſt the ice; neither can they contain proviſions ſufficient for a long navigation. Though the Ruſſians have reſources for ſailing theſe cold ſeas ſuperior to thoſe of moſt other European nations, yet in none of the voyages attempted upon the Frozen Sea has a paſſage been diſcovered between Europe or Aſia to America. It is only by departing from

Kamtſchatka, or ſome other more eaſterly point of Aſia, that the weſterly coaſts of America have ever been diſcovered.

Captain Bering took his departure from port Awatſcha in Kamtſchatka, on the 4th day of June 1741. After ſailing ſouth-eaſt, and then north-eaſt, he diſcovered, on the 18th of July, the continent of America in latitude 58° 28′. Two days after, he anchored near an iſland in the mouth of a bay, from whence he diſcovered two capes, the one to the eaſt he called Saint-Elie, and the other to the weſt Saint-Hermogene. He then diſpatched Chitrou, one of his officers, to reconnoitre the gulf which he had entered: They found that it was interſperſed with iſlands, on one of which they ſaw deſerted cabins made of planks well joined, and even chamfered. They conjectured that this iſland might have been inhabited by ſome people from the continent of America. M. Steller, who was ſent to make obſervations on theſe new diſcovered lands, found a cave, in which were a quantity of ſmoked ſalmon, ropes, furniture, and other utenſils. Advancing ſtill farther, he ſaw the Americans flying from him. He next perceived a fire on a diſtant hill. The ſavages had unqueſtionably retired thither: A rugged and ſteep rock covered their retreat *.

After

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* Hiſt. Gen. des Voyages, tom. 19. p. 371.

After relating theſe facts, it is eaſy to perceive, that it is only by taking their departure from Kamtſchatka that the Ruſſians can carry on commerce with China and Japan, and that it is equally difficult, if not impoſſible, for the other nations of Europe to paſs by the north-eaſt ſeas, the greater part of which are entirely frozen. Hence I cannot heſitate in repeating, that the only poſſible paſſage is by the north-weſt, at the bottom of Hudſon's bay, and that this is the place where all future attempts to diſcover this uſeful paſſage ought to be made.

After the preceding ſheets had been printed, I received from M. le Comte Schouvaloff, that great ſtateſman whom all Europe eſteems and reſpects, an excellent memoir compoſed by M. de Domaſcheneff, preſident of the Imperial Society of Peterſburg, and to whom the Empreſs has aſſigned the department of every thing relating to arts and ſciences. This illuſtrious perſon has likewiſe ſent me a copy of the chart drawn by the pilot Otcheredin, in which are repreſented the tracks and diſcoveries he made in the years 1770 and 1773, between Kamtſchatka and the continent of America. M. de Domaſcheneff, in his memoir, remarks, that this chart of the pilot Otcheredin is moſt exact, and that the one publiſhed in the year 1773 by the Academy of Peterſburg, requires ſeveral amendments, eſpecially with regard to the poſition of the iſlands and the pretended Archipelago, which are repreſented between the Aleutes or Aleoutes iſlands, and thoſe of Anadir, otherwiſe called Andrien. The chart of Otcheredin ſeems to ſhow, that theſe two groups of iſlands, the Aleutes and the iſlands of Andrien, are ſeparated by an open ſea of more than a hundred leagues broad. M. de Domaſcheneff aſſures us, that the great general chart of the Ruſſian empire, publiſhed in the year 1777, gives an accurate repreſentation of all the coaſts on the northern extremity of Aſia inhabited by the Tſchutchis: He ſays, that this chart was executed from the moſt recent diſcoveries made in the laſt expedition of Major Pawluzki againſt that people. 'This coaſt,' ſays M. de Domaſcheneff, 'bounds 'the great chain of mountains which ſeparate 'Siberia from the ſouth of Aſia, and terminates 'by dividing itſelf between the chain that ſtretches 'through Kamtſchatka, and thoſe which 'occupy the territories between the rivers that 'run to the eaſt of the Lena. The known 'iſlands between the coaſts of Kamtſchatka and 'thoſe of America are mountainous, as well as 'the coaſts of Kamtſchatka and thoſe of the 'continent of America. Hence there is a diſtinct 'continuation between the chains of mountains 'belonging to both continents, the intervals of 'which, perhaps leſs conſiderable formerly, may 'have been enlarged by the decaying of rocks,

‘ by the perpetual currents which run from the ‘ Frozen Sea toward the ſouthern ocean, and by ‘ the revolutions which the earth has undergone.’

But this ſub-marine chain which joins the lands of Kamtſchatka to thoſe of America is more ſoutherly, by ſeven or eight degrees, than that of the iſlands of Anadir or Andrien, which, from time immemorial, have ſerved the Tſchutſchis as a paſſage to America.

According to M. de Domaſcheneff, it is certain, that this voyage from the point of Aſia to the continent of America, is performed by oars, and that theſe people go there to diſpoſe of Ruſſian iron-works to the Americans; that the iſlands in this paſſage are ſo frequent, that the ſailors may ſleep every night on land; and that the continent of America, with which the Tſchutſchis traffick, is mountainous, and covered with foreſts, which are full of foxes, martins, and ſables, the qualities and colours of whoſe furs are totally different from thoſe of Siberia. Theſe northern iſlands, ſituated between the two continents, are known to the Tſchutſchis only. They form a chain between the moſt eaſtern point of Aſia and the continent of America, under the 64th degree of latitude; and this chain is divided by an open ſea, from the other more ſouthern chain formerly mentioned, which lies between Kamtſchatka and America, and is under the 56th degree. The iſlands of this ſecond chain the Ruſſians and inhabitants of Kamtſchatka frequent in queſt of ſea-otters, and black foxes, whoſe furs are very precious. Before the year 1750, even the moſt eaſtern of the iſlands which compoſe this chain were known. One of theſe iſlands bears the name of Captain Bering, and another, adjacent to the former, is called the iſland of Medenoi. We next meet with the iſlands of Aleutes or Aleoutes. The two firſt are ſituated a little above, and the laſt a little below the 55th degree of latitude. About the 56th degree, we find the iſlands of Atkhou and Amlaïgh, which are the firſt of the chain called the Iſlands of Foxes: They extend as far to the north-eaſt as the 61ſt degree of latitude. Theſe iſlands have received their denomination from the prodigious number of foxes found in them. The two iſlands of Captain Bering and Medenoi were uninhabited when firſt diſcovered. But, in the iſlands of Aleutes, though advanced farther to the eaſt, more than ſixty families were found, whoſe language had no relation either to that of Kamtſchatka or to any of the oriental languages of Aſia: It is a dialogue of the language ſpoken in the other iſlands adjacent to America, which ſeems to indicate that they have been peopled by the Americans, and not by the Aſiatics.

The iſlands called by Captain Bering's crew Saint-Julian, Saint-Theodor, and Saint-Abraham,

ham, are the ſame with thoſe which now receive the name of Aleutes. In the ſame manner, the iſlands of Chommaghin and Saint-Dolmat, diſcovered by this navigator, form a part of thoſe now called the Iſlands of Foxes.

'The great diſtance,' ſays M. de Domaſcheneff, 'and the open and deep ſea between the 'iſlands of Aleutes and thoſe of Foxes, joined 'to the different direction of the latter, render 'it probable, that theſe iſlands never formed one 'continued chain, but that the former, with 'thoſe of Medenoi and Bering, make a chain 'which comes from Kamtſchatka; that the 'Iſlands of Foxes exhibit another paſſage to 'America; and that both of theſe chains generally 'loſs themſelves in the depth of the ocean, and 'are promontories to the two continents. The 'courſe of the Iſlands of Foxes, ſome of which 'are of great extent, is intermixed with rocks 'and breakers, and continues without interruption as far as the continent of America. But 'thoſe moſt adjacent to this continent are very 'little frequented by the Ruſſian hunters; because they are very populous, and it would be 'dangerous to ſojourn in them. There are ſeveral iſlands in the neighbourhood of America 'which are ſtill little known. Some ſhips, however, have penetrated as far as the iſland of 'Kadjack, which is very near the continent 'of America. We are aſſured of this fact by the 'relation of the iſlanders; and other circumſtances confirm the truth of their aſſertion: All the iſlands that lie more to the weſt, produce only dwarfiſh and miſ-ſhapen ſhrubs, which the winds from the open ſea prevent from riſing higher. The iſland of Kadjack, on the contrary, and the ſmall adjacent iſlands, produce groves of alder-trees, which ſeem to indicate that they are leſs expoſed, and that they are ſheltered on the north and eaſt by a neighbouring continent. Beſides, in Kadjack, we find freſh water otters, which appear not in the other iſlands; and we likewiſe find a ſmall ſpecies of marmot, which ſeems to be the marmot of Canada. Laſtly, we diſcover, in that iſland, traces of the bear and wolf; and the inhabitans çlothe themſelves with rain-deers ſkins brought to them from the continent of America, to which they lie very contiguous.

'From a voyage to the iſland of Kadjack, conducted by one Geottof, we learn, that the continent of America is called *Atakthan* by the iſlanders: They ſay, that this great land is mountainous and covered with foreſts; that it is ſituated to the north of their iſland; and that the mouth of a great river there goes by the name of *Alaghſchak*. Beſides, it is unqueſtionable, that Bering, as well as Tſchirikow, actually reached this great continent;

‘ for, at Cape Elie, where Bering moored his ‘ frigate, they ſaw the coaſt riſe into a chain ‘ of mountains which were covered with thick ‘ foreſts. The ſoil was of a nature totally different from that of Kamtſchatka; and Steller ‘ collected a number of American plants.’

M. de Domaſcheneff farther obſerves, that all the Iſlands of Foxes, as well as thoſe of Aleutes and Bering, are mountainous; that their coaſts are rocky, often terminate in precipices, and are ſurrounded to a conſiderable diſtance with rocks; that the country riſes, from the coaſts to the middle of theſe iſlands, into rugged mountains, which form ſmall chains through the whole length of each iſland. Beſides, there have been, and ſtill are, volcano’s in ſeveral of theſe iſlands; and in thoſe where the volcano’s are extinguiſhed, there are fountains of hot water. In the iſlands with the volcano’s, no metals are found, but only calcedons and ſome other coloured ſtones of no value. In theſe iſlands, the inhabitants have no other wood but what is floated into them by the ſea, and the quantity is not great. More wood arrives in the iſland of Bering and the Aleutes. This floated wood ſeems to come from the ſouth; for the camphor tree of Japan has been found on the coaſts of theſe iſlands.

The inhabitants are pretty numerous; but, as they lead a wandering life, and tranſport themſelves from one iſland to another, it is not poſſible to aſcertain their number. It has been remarked, in general, that the larger the iſlands are, they are the nearer America, and the more populous. It likewiſe appears, that all the inhabitants of the Iſlands of Foxes are of the ſame nation, to which thoſe of the Aleutes and the iſlands of Andrien may alſo be referred, though they differ in ſome cuſtoms. All theſe people, in their manners, modes of living, and of feeding, have a great reſemblance to the Eſquimaux and the Greenlanders. *Kanaghiſt*, the name of theſe iſlanders in their own language, and perhaps corrupted by the mariners, has ſtill a great affinity to *Karalit*, the denomination of the Eſquimaux and their brethren the Greenlanders. Among the inhabitants of all the iſlands between Aſia and America, no other utenſils were found but ſtone-hatchets, flint-knives, and the ſhoulder bones of animals ſharpened to cut herbage. They have likewiſe darts armed with ſharp flints, and moſt artfully cut. They have now a great many implements of iron, which they have obtained from the Ruſſians. They make canoes like the Eſquimaux; ſome of them are ſo large that they contain twenty perſons. They are made of light wood, and are entirely covered with the ſkins of ſeals and other ſea-animals.

From all theſe facts, it appears, that, from time immemorial, the Tſchutſchis, who inhabit the eaſtern point of Aſia between the 55th and 70th degree of latitude, have had commerce with the Americans; that this intercourſe was the more eaſy to a people accuſtomed to all the rigours of cold; and that the voyage, which perhaps exceeds not a hundred leagues, might be performed in ſimple canoes, conducted by oars in ſummer, and probably on the ice in winter, by landing daily upon a different iſland. America, therefore, might be peopled by Aſia under this parallel; and every circumſtance ſeems to indicate, that, though there are now intervals of ſea between theſe iſlands, they formerly conſtituted but one continent, by which America was joined to Aſia. It is likewiſe probable, that, beyond the iſlands of Anadir or Andrien, *i. e.* between the 70th and 75th degree of latitude, the two continents are abſolutely united, though that track of land is perhaps entirely covered with ſnow and ice. To explore the regions beyond the 70th degree is an enterpriſe worthy of the great Sovereign of the Ruſſias, and it ought to be entruſted to a navigator equally intrepid as Captain Phipps. I am perſuaded, that they would find the two continents united; but, if otherwiſe, and if there is an open ſea beyond the iſlands of Andrien, it appears to be certain, that they would find the projections of the great Polar glacier at the 81ſt or 8d degree, as Captain Phipps diſcovered them at the ſame latitude between Spitzbergen and Greenland.

Concerning that period when the powers of Man aided thoſe of Nature.

The firſt men were witneſſes of the convulſive motions of the earth, which were then frequent and terrible. For a refuge againſt inundations, they had nothing but the mountains, which they were often forced to abandon by the fire of volcano's. They trembled on ground which trembled under their feet. Naked in mind as well as in body, expoſed to the injuries of every element, victims to the rapacity of ferocious animals, which they were unable to combat, penetrated with the common ſentiment of terror, and preſſed by neceſſity, they muſt have quickly aſſociated, at firſt to protect themſelves by their numbers, and then to afford mutual aid to each other in forming habitations and weapons of defence. They began with ſharpening into the figure of axes thoſe hard flints, thoſe *thunder-ſtones*, which their deſcendants imagined to have been produced by thunder, and to have fallen from the clouds, but which, in reality, are the firſt monuments of human art. They would ſoon extract fire from theſe flints by ſtriking them againſt each other.

To deſtroy the bruſhwood and the foreſts, they would employ the flames derived from volcano's, or from their burning lavas; for, with the aſſiſtance of this powerful element, they cleared and purified the grounds which they choſe to inhabit. With the axes of ſtone, they cut trees, and fabricated thoſe weapons and utenſils of which neceſſity firſt ſuggeſted the uſe; and, after being provided with clubs and other heavy armour, would not theſe firſt men diſcover the means of making lighter weapons to annoy at a diſtance? The tendon of an animal, the fibres of aloes, or the pliant bark of ſome ligneous plant, would ſerve them for a cord to unite the extremities of an elaſtic branch; with which they made their bow: To arm their arrows, they employed ſmall ſharp flints. In a ſhort time they would have thread, rafts, and canoes; and in this ſtate they would remain till little nations were formed. Theſe nations were compoſed of a few families, or rather of the deſcendants of the ſame family, which is ſtill the condition of thoſe ſavages who live independent in ſuch open and ſpacious territories as afford them game, fiſhes, and fruits. But, in territories which are narrowed by waters, or confined by high mountains, theſe ſmall nations, after a great increaſe of population, were obliged to divide the land among themſelves; and, from this moment, the earth became the inheritance of man. He took poſſeſſion of it by his labour and cultivation; and the attachment to a native ſoil followed rapidly the firſt acts of property. As individual intereſt conſtitutes a part of national order, government and laws muſt have ſucceeded, and ſociety muſt have aſſumed ſtrength and conſiſtence.

Nevertheleſs, theſe men, deeply affected with the miſeries of their original ſtate, and having ſtill before their eyes the ravages of inundations, the conflagrations of volcano's, and gulfs opened by the ſuccuſſions of the earth, have preſerved a durable, and almoſt eternal, remembrance of the calamities the world has ſuffered. The idea, that it muſt periſh by an univerſal deluge, or by a general conflagration; the reverence for certain mountains upon which they had been ſaved from inundations; their horror at others which threw out fires more dreadful than thoſe of thunder; the view of thoſe combats between the earth and heavens, which gave riſe to the fable of the Titans, and of their aſſaults againſt the Gods; the notion of the real exiſtence of a malevolent being, with the terror and ſuperſtition which it unavoidably produced; all theſe ſentiments, founded upon fear, took an unconquerable poſſeſſion of the human mind. Even at preſent, men are not entirely emancipated from theſe ſuperſtitious terrors by the experience of time, by the tranquillity which ſucceeded thoſe ages of convulſions and ſtorms, nor by the knowledge of the effects and operations of Nature, a knowledge which could not be acquired till after the eſtabliſhment of ſome great ſociety in a tranquil land.

It is neither in Africa, nor in the moſt ſouthern regions of Aſia, that great ſocieties or nations could be firſt formed. Theſe countries were ſtill burning and deſert. Neither could this event happen in America, which, except its chain of mountains, is evidently a new country; nor even in Europe, which very lately derived its learning from the Eaſt, where the firſt civilized men were eſtabliſhed; for, before the foundation of Rome, the happieſt countries in this part of the world, ſuch as Italy, France, and Germany, were then peopled with men more than half ſavage. Tacitus, in his Manners of the Germans, exhibits a picture of thoſe of the Hurons, or rather of men juſt emerging from a ſtate of nature. Hence the ſource of human knowledge muſt have ariſen in the northern countries of Aſia; and power is a neceſſary reſult of knowledge. The more man knows, the more he can perform; and the leſs he has done, the leſs he knows. All this implies an active people in a happy climate, living under a pure ſky and in a fertile country, remote from inundations and volcano's: It muſt alſo have been a high country, and, of courſe, more anciently temperate than the more ſouthern regions. Now, all theſe conditions, all theſe circumſtances, are united in the centre of Aſia, from the 40th to the 55th degree of latitude. The rivers which run into the North Sea, into the Eaſtern Ocean, and into the South and Caſpian Seas, take their riſe from this elevated region, which at preſent compoſes the ſouthern part of Siberia and of Tartary. It is, therefore, in this country, which is more elevated than all the others, ſince it ſerves them as a centre, and is near five hundred leagues from any ocean; it is in this privileged country that the firſt people worthy of notice were produced; and they merit our eſteem as the inventors of arts, ſciences, and every uſeful inſtitution. This truth is equally evident from the monuments of natural hiſtory, and from the almoſt inconceivable progreſs of aſtronomy. How could men ſo new invent the luniſolar period of ſix hundred years? I confine myſelf to this ſingle fact, though many others equally wonderful and permanent might be produced. Theſe people, therefore, knew as much of aſtronomy as was known in the days of Caſſini, who firſt demonſtrated the reality and exactneſs of this period of ſix hundered years; a knowledge of which the Chaldeans, Egyptians, and Greeks, were perfectly ignorant; a knowledge which preſuppoſes that of the exact movements of the earth and moon, and requires great perfection in the inſtruments neceſſary to make obſervations; a knowledge, which, as it implies the acquiſition of every thing derived from a long ſucceſſion of aſtronomical ſtudy and reſearch, muſt have required at leaſt two or three thouſand years exertion of the human mind.

Theſe firſt people, becauſe they had become very learned, muſt have been proportionally happy. They muſt have enjoyed many ages of peace and leiſure, which are neceſſary for the cultivation of ſcience. Before they could entertain a ſuſpicion concerning the period of ſix hundred years, at leaſt twelve hundred years of aſtronomical obſervations were requiſite; and, to aſcertain the fact, more than double that number of years were neceſſary. Thus we have already about three thouſand years employed in aſtronomical ſtudies: Neither ſhould this circumſtance ſurpriſe us; for, in reckoning from the Chaldean aſtronomers to the preſent day, an equal time has been employed in diſcovering this period of ſix hundred years. Beſides, theſe three thouſand years of aſtronomical obſervations muſt neceſſarily have been preceded by many ages in which ſcience was unknown Nay, are ſix thouſand years from the preſent time ſufficient to diſcover the moſt noble epoch in the hiſtory of man, or even to trace his gradual progreſs in the arts and ſciences?

But, unhappily theſe ſublime and beautiful ſciences are loſt: We can only recogniſe their paſt exiſtence by deformed and imperfect fragments. The invention of the *formula* by which the Brahmins calculate eclipſes, preſuppoſes as much ſcience as the conſtruction of our Ephemerides; and yet theſe Brahmins have not the ſmalleſt idea of the ſtructure of the univerſe. They poſſeſs only ſome falſe notions concerning the motion, magnitude, and poſition of the planets. They calculate eclipſes without knowing the theory of them. This operation they are enabled to perform by machines or tables founded upon learned formulae, which they do not comprehend, and which, probably, were not invented by their anceſtors; becauſe they have never brought any thing to perfection, and have not tranſmitted the ſmalleſt ray of ſcience to their deſcendants. In their hands, theſe formulae are only practical methods; but they imply profound knowledge, of which theſe people have not preſerved the ſlighteſt veſtige, and which, of courſe, they have never poſſeſſed. Hence theſe methods could only proceed from that ancient people, who had reduced into formulae the motion of the ſtars, and who, by a long courſe of obſervations, could not only predict eclipſes, but, what is much more difficult, they recogniſed the period of ſix hundred years, and, of courſe, were acquainted with all thoſe aſtronomical facts which this diſcovery neceſſarily required.

I may affirm, that the Brahmins never invented theſe formulae; becauſe all their phyſical ideas are contrary to the theory on which theſe formulae depend. If they had comprehended this theory, even at the time they received its reſults, the ſcience would have been preſerved, and they would not, as they do at preſent, have entertained the moſt abſurd and ignorant notions concerning the ſyſtem of the univerſe; for they believe that the earth is immoveable, and is ſupported by a mountain of gold; that the moon is eclipſed by aerial dragons; that the planets are ſmaller than the moon, &c. It is therefore evident, that they never had the firſt elements of aſtronomical theory, nor the ſmalleſt knowledge of the principles upon which the methods they employ depend *.

The Chineſe, who are a little more enlightened than the Brahmins, calculate eclipſes in a very rude manner, and they have continued to calculate them in the ſame manner for two or three thouſand years. As they bring nothing to perfection, they can never invent. Hence ſcience neither originated in China nor in India. Though equally near as the Indians to the firſt learned people, the

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* For a more complete view of this ſubject, I refer the reader to an excellent account of ancient aſtronomy lately publiſhed by Bailly, whoſe ideas perfectly coincide with mine.

the Chineſe appear not to have derived any advantage from this favourable ſituation. They are not even poſſeſſed of thoſe aſtronomical formulae of which the Brahmins have preſerved the uſe, and which conſtitute the firſt great monuments of the knowledge and happineſs of man. Neither does it appear that the Chaldeans, Perſians, Egyptians, or Greeks, received any advantage from this firſt enlightened race of men; for, in theſe Levant countries, the new aſtronomy muſt be aſcribed to the indefatigable aſſiduity of the Chaldean obſervers, and afterwards to the labour of the Greeks, which can only be dated from the foundation of the Alexandrian ſchool. This ſcience, however, after the culture of two thouſand years, and even till theſe two or three laſt centuries, was very imperfect. It ſeems, therefore, to be certain, that theſe people, who firſt invented, and for a long ſucceſſion of ages ſo happily cultivated aſtronomy, have left nothing but ſome fragments, ſome reſults of the ſcience, which might be retained in the memory, ſuch as that of the period of ſix hundred years, which has been tranſmitted to us by Joſephus the Jewiſh hiſtorian, who did not underſtand its value or import.

The loſs of the ſciences, that firſt wound to humanity inflicted by the ſword of barbarity, muſt have been the effect of ſome direful revolution, which, in a few years perhaps, deſtroyed the labours and the ingenuity of many ages; for thoſe firſt powerful and learned people muſt have continued long in a ſtate of ſplendour and proſperity, ſince they made ſo great progreſs in the ſciences, and, of courſe, in all the arts which the ſtudy of them neceſſarily require. But it is extremely probable, that, when the regions to the north of this happy country, had become too cold, their inhabitants, ſtill ignorant, ferocious, and barbarous, would pour in upon this rich and cultivated country. It is even aſtoniſhing, that theſe barbarians ſhould have been able to annihilate not only the principles, but the remembrance of all ſcience. Three thouſand years of ignorance, perhaps, followed the three thouſand years of light and knowledge which had preceded them. Of all theſe firſt and beautiful fruits of the human genius, there now remains nothing but a metaphyſical religion, which, being incomprehenſible, required no ſtudy, and could neither be altered nor loſt but by a defect of memory, which never fails when it is ſtruck with the marvellous. From this firſt centre of the Sciences, the ſame metaphyſical religion diffuſed itſelf over every quarter of the globe. The idols of Calicut are the ſame with thoſe of Seleginſkoi. Pilgrimages to the great Lama are undertaken at the diſtance of more that two thouſand leagues. The idea of the metempſycoſis, or tranſmigration of ſouls, extends

tends ſtill farther, and is adopted as an article of faith by the Indians, the Æthiopians, and the Atlantes. The ſame notions, a little diſguiſed, were received by the Chineſe, Perſians, Greeks, and Romans. Every circumſtance concurs in proving, that the firſt common ſtem of human knowledge aroſe in this region of Aſia *, and that its barren or degenerated branches extended into every part of the earth.

The paſt ages of barbarity are for ever buried in profound darkneſs. Men were then ſo deformed with ignorance, that human nature was hardly recogniſable: For rudeneſs, followed by the neglect of duty, began to relax the bonds of ſociety, which were afterwards torn aſunder by barbarity; the laws were deſpiſed or proſcribed; manners degenerated into habits of ferocity; the love of ſociety, though engraven on the human heart, was totally effaced; in a word, man, without education, without morals, was reduced to lead a ſolitary and ſavage life, and, inſtead of the high dignity of his nature, preſented the picture of a being degraded below the brutes.

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* The learned M. Pallas remarks, that the cultivation, the arts, and the towns thinly ſcattered through this region, are living monuments of an empire or flouriſhing ſociety, whoſe hiſtory is buried with its cities, temples, and arms, of which enormous ruins are daily dug out of the earth. Theſe ſcattered people are the members of a great nation, which has no head. *Voyage de Pallas en Siberie.*

However, after the loſs of the ſciences, the uſeful arts to which they had given birth were preſerved. The cultivation of the earth, which became more neceſſary in proportion to the increaſe of population; all the arts and practices which this culture requires, as well as all thoſe employed in the conſtruction of buildings, in the fabrication of idols and arms, in the weaving of ſtuffs, &c. ſurvived the ſciences. Theſe arts were gradually diffuſed and brought to perfection: They followed the courſe of population. The ancient empire of China firſt aroſe, and nearly at the ſame time that of the Atlantes in Africa. The empires on the continent of Aſia, thoſe of Egypt and Æthiopia, were ſucceſſively eſtabliſhed, and, laſtly, that of Rome, to which our Europe owes its civil exiſtence. Hence, about three thouſand years only have elapſed ſince the power of man united with that of Nature, and ſpread over the greateſt part of the earth. Before this period, the treaſures of fertility were buried. The other reſources of man, ſtill more profoundly interred, could not elude his reſearches, but have become the reward of his labours. When he conducted himſelf with wiſdom, he followed the leſſons of Nature; he derived advantage from her examples; he employed her means, and, from the immenſity of her productions, ſelected all thoſe objects from which he could derive either utility or pleaſure.

By his intelligence the animals were ſubdued, tamed, and reduced to perpetual ſlavery. By his labours, the marſhes were drained, the rivers were reſtrained, and their cataracts effaced, the foreſts were cleared, and the earth cultivated. By his reflection, times were computed, ſpaces were meaſured, the celeſtial motions were recogniſed, combined, and repreſented, the heavens and the earth were compared, the univerſe was augmented, and the Creator worthily adored. By his art, which is an emanation of ſcience, the ſeas have been traverſed, and the mountains overcome; nations have been united; a new world has been diſcovered; a thouſand other detached lands have been reduced under his dominion; laſtly, the whole face of the earth at preſent exhibits the marks of his power, which, though ſubordinate to that of Nature, often exceeds, at leaſt, ſo wonderfully ſeconds her operations, that, by the aid of his hands, her whole extent is unfolded, and ſhe has gradually arrived at that point of perfection and magnificence in which we now behold her.

Compare rude with cultivated Nature. Compare the ſmall ſavage nations of America with thoſe of our civiliſed people, or even with thoſe of Africa, who are only half cultivated. Contemplate the condition of the lands which thoſe nations inhabit, and you will eaſily perceive the inſignificance of men who have made ſo little impreſſion on their native ſoil. Whether from ſtupidity or indolence, theſe brutiſh men, theſe unpoliſhed nations, great or ſmall, give no ſupport to the Earth; they ſtarve without fertilizing her; they devour every thing, and propagate nothing. The ſavage ſtate, however, is not the moſt deſpicable condition of mankind, but that of thoſe nations who have juſt begun to be poliſhed, who have always been the real ſcourges of human nature, and who, even at preſent, can hardly be reſtrained by the people who are completely civiliſed. They have, as formerly remarked, ravaged the firſt happy land. They have torn up the germs of happineſs, and deſtroyed the fruits of ſcience. How many invaſions have ſucceeded this firſt irruption of barbarians? From theſe ſame northern regions, where every human virtue formerly exiſted, all our evils afterwards proceeded. How often have we ſeen theſe irruptions of animals with human faces, who always come from the north, ravage the countries of the ſouth? Conſult the annals of all nations, and you will find twenty ages of deſolation, for a few years of eaſe and tranquillity.

Nature required ſix hundred ages to conſtruct her great works, to temper the earth, to faſhion its ſurface, and to arrive at repoſe: How many ages would men require before they ceaſed to diſturb and deſtroy each other? When will they learn, that the peaceble poſſeſſion of their own country is ſufficient for their happineſs? When will they be wiſe enough to give up their falſe pretenſions, to renounce imaginary dominions, and diſtant poſſeſſions, which are often ruinous, or at leaſt coſt more than their value? The Spaniſh empire in Europe is as extenſive as that of France, and ten times larger in America; Is it ten times more powerful? Is it even as powerful as if this bold and great nation were limited to derive from its own happy country all the benefits which it could furniſh? Have not the Britiſh, a people ſo ſenſible, and ſuch profound thinkers, committed a great error by extending too far the limits of their colonies? The ancients appear to have had more correct ideas with regard to theſe eſtabliſhments. They never projected emigrations till their population was too great, and their territory and commerce were not ſufficient to ſupply their wants. Have not the invaſions of barbarians, which we look upon with horror, had cauſes ſtill more preſſing, when they found themſelves too numerous in ungrateful, cold, and naked countries, and at the ſame time ſurrounded with fertile and cultivated lands, which produced every article they required? But, what quantities of blood, what calamities, what loſſes, have accompanied and followed theſe direful conqueſts?

We ſhall dwell no longer on the diſmal ſpectacle of thoſe revolutions of death and devaſtation, which are the genuine effects of ignorance. Let us entertain the agreeable hopes, that the balance, though imperfect, which ſubſiſts between cultivated nations, will continue, and become even more ſtable in proportion as men ſhall have better notions of their real intereſt; that they will learn the value of peace and tranquil happineſs; that the acquiſition of this object will be the chief aim of their ambition; and that Princes will diſdain the falſe glory of conquerors, and deſpiſe the little reſtleſs vanity of thoſe who excite them to ſuch dreadful commotions.

Let us ſuppoſe the world in peace, and take a nearer proſpect of the influence of man's power over that of Nature. Nothing appears to be more difficult, not to ſay impoſſible, than to oppoſe the ſucceſſive cooling of the earth, and to warm the temperature of a climate; yet this feat man can and has performed. Paris and Quebeck are nearly under the ſame degeee of latitude; Paris, therefore, would be as cold as Quebeck, if France and the adjacent countries were as thinly inhabited, and as much covered with wood and water as the territories in the neighbourhood of Canada. The draining, clearing, and peopling a country, will give it a warmth which will continue for ſome thouſand years; and this fact will prevent the only reaſonable objection which can be made againſt my opinion, that the earth is gradually cooling.

According to your ſyſtem, it may be ſaid, the whole earth muſt be cooler now than it was two thouſand year ago: But tradition proves the contrary. France and Germany formerly produced rain-deer, lynxes, bears, and other animals which have ſince retired to more northerly regions. This progreſs is very different from what you maintain, namely, from north to ſouth. Beſides, hiſtory informs us, that the river Seine was annually frozen during a part of the winter. Are not theſe facts a direct contradiction to the gradual cooling of the earth? They would, I acknowledge, if France and Germany were now in the ſame ſtate; if we had not cut down the foreſts, drained the marſhes, confined the torrents, directed the rivers, and cleared all the lands which were overgrown with unprofitable plants. But we ought to conſider, that the heat of the globe diminiſhes in an imperceptible manner; that ſeventy-two thouſand years were neceſſary to cool it to a proper temperature, and that an equal portion of time muſt elapſe before it is ſo cold as to be unfit for the nouriſhment of animals and vegetables. We muſt conſider the difference between this ſlow cooling of the earth and the ſudden colds produced in the atmoſphere; and we muſt nevertheleſs recollect, that the difference

ence between the greateſt heat of our ſummers, and the greateſt cold of our winters, exceeds not a thirty-ſecond part. From theſe conſiderations it is apparent, that external cauſes have a much greater influence upon the temperature of every climate than the internal cauſe, and that, in all thoſe climates where the cold of the ſuperior regions of the air is attracted by moiſture, or puſhed by the winds towards the ſurface, the effects of theſe particular cauſes are much more powerful than that produced by the general cauſe. Of this we ſhall give an example, which will remove every doubt, and at the ſame time obviate every ſimilar objection.

In the immenſe territories of Guiana, which are covered with thick foreſts, where the ſun can hardly penetrate, where great tracts of country are overflowed with water, where the rivers are very near each other, and are neither reſtrained nor directed, where it rains continually during eight months of the year, the inhabitants, about a century ago, began to clear the country arround Cayenne, which is a very ſmall canton of theſe vaſt foreſts. The difference of temperature in this little diſtrict is already ſo perceptible, that the people are too warm during the night; but, in all the lands which are covered with wood, the nights are ſo cold that fires are neceſſary in the houſes. The ſame effect is produced with regard to the quantity and duration of the rains · They ceaſe ſooner and commence later at Cayenne than in the interior parts of the country ; neither are they ſo heavy, nor ſo frequent. At Cayenne, there are four months of abſolute drineſs : But, in the interior parts of the country, the dry ſeaſon laſts only three months ; beſides, a daily rain is brought down by the ſouth winds, which is pretty violent. Another circumſtance merits attention : It ſeldom thunders at Cayenne ; but, in the interior parts, where the clouds are black, thick, and very low, the thunder is violent and very frequent. Theſe facts ſhow, in the cleareſt manner, that, in this country, the eight months of perpetual rain might be diminiſhed, and the heat greatly augmented, if the foreſts were cut down, if the waters were reſtrained, and the rivers properly directed, and if the cultivation of the earth, which ſuppoſes the movements of a great number of men and animals, baniſhed that cold and ſuperfluous moiſture which is attracted and diffuſed by the immenſe quantity of vegetables.

As every action, every movement, produces heat, and as all beings endowed with the faculty of progreſſive motion, may be conſidered as ſo many little fires, it is in proportion to the number of men and animals, that (every thing elſe being equal) the local temperature of each particular country depends. The former diffuſe heat, the latter nothing but cold and moiſture. The perpetual uſe men make of fire adds greatly to the artificial temperature of all populous territories. In Paris, during great colds, the thermometers at the Faubourg Saint-Honoré ſtand two or three degrees lower than thoſe at the Faubourg Saint-Merceau; becauſe the north wind is heated in paſſing over the numerous chimneys of that great city. A ſingle foreſt in any country is ſufficient to produce ſome change in its temperature. Trees attract the cold; by their ſhade they diminiſh the heat of the ſun; they produce moiſt vapours that form clouds and fall down in rain, which is always colder from the greater height it deſcends. When theſe foreſts are abandoned to Nature alone, the old trees fall and coldly corrupt; but, when under the dominion of man, they are uſed as fewel to the element of fire, and become the ſecondary cauſes of every particular heat. In meadows, before the herbage is cut down, there are always copious dews, and often ſmall ſhowers of rain, which ceaſe as ſoon as the graſs is carried off. Theſe ſmall rains would become more abundant and more durable, if our meadows, like the ſavannahs of America, were always covered with the ſame quantity of herbs, which, inſtead of diminiſhing, muſt increaſe by the accumulating manure of all thoſe that die and corrupt on the ſurface.

Many other examples might be given, all concurring to ſhow that man can have an influence on the climate he inhabits, and, in a manner, fix its temperature at any point that may be agreeable to him; and, what is ſingular, it is more difficult for him to cool than to heat the earth. He is maſter of the element of fire, which he can augment and propagate at pleaſure, but not of the element of cold, which he can neither lay hold of nor communicate. The principle of cold is not a real ſubſtance, but a ſimple privation, or rather diminution of heat; a diminution which ought to be very great in the high regions of the air, and which, at the diſtance of a league from the earth, converts the aqueous vapours into hail and ſnow. For the emanations of the heat proper to the globe obſerve the ſame law as all other phyſical quantities or qualities which proceed from a common centre; and, as their intenſity decreaſes in the inverſe ratio of the ſquare of the diſtance, it appears to be certain, that the atmoſphere is four times colder at the height of two leagues than at that of one, each point of the earth's ſurface being conſidered as a centre. On the other hand, the interior heat of the globe, in every ſeaſon, is conſtantly ten degrees above the freezing point. Hence the earth can never be colder than ten degrees above this point, except by the fall of cold matters upon its ſurface from the ſuperior regions of the air, where the effects of the internal heat of the globe diminiſh in proportion to the height. Now, the power of man extends not ſo far. He cannot make cold deſcend, as he makes heat aſcend. He has no other mode of defending himſelf from the ardour of the ſun's rays, but by forming a ſhade. But it is more eaſy to cut down the foreſts of Guiana, in order to heat the humid earth, than to plant trees in Arabia to refreſh the burning ſands. A ſingle foreſt, however, in the midſt of theſe parched deſerts, would be ſufficient to render them more temperate, to attract the waters from the atmoſphere, to reſtore all the principles of fertility to the earth, and, of courſe, to make man, in theſe barren regions, enjoy all the ſweets of a temperate climate.

It is upon the difference of temperature that the ſtronger or weaker energies of Nature depend. The growth, and even the production, of all organized beings, are only particular effects of this general cauſe: Hence man, by modifying this cauſe, may in time deſtroy what injures him, and give birth to every thing that is agreeable to his feelings. Happy are thoſe countries where all the elements of temperature are balanced, and ſo fortunately combined as to produce only good effects! But, has any country, from its origin, ever enjoyed this privilege? Is there any country where the power of man has not aided that of Nature, either by attracting or diſſipating the waters, by deſtroying noxious or ſuperfluous vegetables, and by taming and multiplying uſeful animals? Of three hundred ſpecies of quadrupeds, and fifteen hundred ſpecies of birds, man has ſelected nineteen or twenty *; and theſe twenty ſpecies make a greater figure in Nature, and are more uſeful to the earth than all the others: They make a greater figure, becauſe they are directed and prodigiouſly multiplied by man. By co-operating with him, they produce all the benefits which could be expected from a wiſe diſtribution of powers in cultivating the earth, in tranſporting the articles of commerce, in augmenting proviſions, in ſupplying all the wants, and in miniſtering to the pleaſures of their only maſter who can reward their ſervices by his induſtry and attention.

Of the ſmall number of animals ſelected by man, the hen and the hog ſpecies, which are the moſt prolific, are likewiſe the moſt generally diffuſed, as if the aptitude for great multiplication were accompanied with that vigour of conſtitution which braves every danger or inconveniency ariſing from difference of climate. The hen and the hog have been found in the moſt unfrequented regions of the earth, in Otaheite and other ſouthern iſlands, which are the moſt remote

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* The elephant, the camel, the horſe, the aſs, the ox, the ſheep, the goat, the hog, the dog, the cat, the lama, the vigogne, the buffalo; the hen, the ſwan, the guiney hen, the duck, the peacock, the pheaſant, and pigeon.

remote from any continent, and have, till very lately, remained for ever unknown. It appears that theſe ſpecies have followed man in all his emigrations. In ſouth America, where none of our animals could poſſibly arrive, we find the pecari and wild hen, which, though ſmaller and a little different from the hog and hen of our continent, muſt be regarded as a ſpecies ſo much allied that they might eaſily be reduced to a domeſtic ſtate. But ſavage man, having no idea of ſociety, is not ſollicitous about that of animals. In the regions of ſouth America, the ſavages have no domeſtic animals. They deſtroy indifferently the good with the bad ſpecies. They ſelect none for the purpoſes of rearing and multiplying them; while a ſingle fertile ſpecies, like that of the *hocco* *, which is at their command, would furniſh them, with very little attention, more ſubſiſtance than they can procure by their laborious and painful huntings.

Thus the firſt mark of man's civilization is the empire he aſſumes over the animals; and this firſt mark of his intelligence becomes afterwards the greateſt evidence of his power over Nature: For it is only after he ſubjugates and tames animals, that he is enabled, by their aſſiſtance, to change the face of the earth, to convert deſerts into fertile ground, and heath into corn. By multiplying uſeful animals, he augments the quantity of life and motion on the ſurface of the earth; he, at the ſame time, improves the whole race of beings, and ennobles himſelf, by transforming the vegetable into the animal, and both into his own ſubſtance, which afterwards diffuſes itſelf by a numerous multiplication. He every where produces plenty of proviſions, which is always ſucceeded by great population. Millions of men exiſt in the ſame ſpace which was formerly occupied by two or three hundred ſavages, and millions of animals where only a few individuals exiſted. By him, and for his uſe, all the precious germs are unfolded; the productions of the nobleſt kinds are alone cultivated; upon the immenſe tree of fecundity the fruitful branches are alone brought to perfection.

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* A large and very prolific bird, whoſe fleſh is as good as that of the pheaſant.

Grain, of which man makes bread, is not the gift of Nature, but the fruit of his reſearches and of his knowledge in the firſt of all arts. In no quarter of the earth has wild corn been ever found: It is evidently an herb brought to perfection by his care and induſtry. This precious plant he muſt have ſelected out of many thouſands. He muſt have ſown and reaped a number of times, in order to diſcover its fertility, which is always proportioned to the manure and culture beſtowed upon the ſoil: And the ſingular quality poſſeſſed by wheat of reſiſting, in its early ſtate, the cold of our winters, though, like all other annual plants, it periſhes after yielding its ſeed, and its no leſs wonderful qualities of being nutritious and agreeable to all men, to many animals, accommodated to almoſt every climate, and can be long preſerved without corruption, and without loſing its power of reproduction; all theſe circumſtances concur in proving that it is the moſt happy invention ever diſcovered by man; and, however ancient it may be ſuppoſed, it muſt have been preceded by the art of agriculture founded upon ſcience, and brought to perfection by experience and obſervation.

If more modern and even recent examples of man's power over the nature of vegetables are required, we have only to compare our potherbs, our flowers, and our fruits with thoſe of the ſame ſpecies as they exiſted fifty years ago. This compariſon may be inſtantly made, by inſpecting the great collection of flowers, which was begun in the time of Gaſton d'Orleans, and continued to this day, in the Royal Garden. We ſhall then perceive, perhaps with ſurpriſe, that the moſt beautiful flowers of that period, as the ranunculi, pinks, tulips, auricula, &c. would now be rejected, not by floriſts alone, but by the moſt vulgar gardeners. Theſe flowers, though then cultivated, were not far removed from their natural ſtate. A ſingle row of petals or flower leaves, long ſtamina, and hard or diſagreeable colours, without variety, and without delicate ſhades, are the ruſtic characters of ſavage nature. Our pot-herbs conſiſted of a ſingle ſpecies of ſuccory, and two of lattuce, both very bad; but we have now more than fifty kinds of lattuce and ſuccory, all of which are good. Our beſt fruits and nuts, which are ſo different from thoſe formerly cultivated, that they have no reſemblance but in the name, muſt likewiſe be referred to a very modern date. In general, ſubſtances remain, and names change with times. But, in this caſe, names remain, and ſubſtances are changed. Our peaches, our apricots, our pears, are new productions with ancient names. To remove every doubt upon this ſubject, we have only to compare our flowers and fruits with the deſcriptions, or rather notices of them, tranſmitted to us by the Greeks and Romans. All their flowers were ſingle, and all their fruit trees were wild ſtocks, and their ſpecies very ill choſen: Their fruits, of courſe, were ſmall, dry, ſour, and had neither the flavour nor the beauty of ours.

Theſe new and good ſpecies originally ſprung from the wild kinds; but, how many thouſand times have their ſeeds been ſown before this happy effect was produced? It was only by ſowing and rearing an infinite number of vegetables of the ſame ſpecies, that ſome individuals were recogniſed to bear better and more ſucculent fruit than others; and this firſt diſcovery, which ſuppoſes much care and obſervation, would have remained for ever uſeleſs, if a ſecond had not been made, which implies an equal degree of genius as the firſt required of patience; I mean the mode of multiplying by engrafting thoſe precious inviduals, which unfortunately cannot propagate, or tranſmit their excellent qualities to their poſterity. This fact alone ſhows that theſe qualities are purely individual, and not ſpecific; for the ſeeds of theſe excellent fruits, like the inferior kinds, produce nothing but wild ſtocks, which are eſſentially different.

By means of engrafting, however, man has in a manner created ſecondary ſpecies, which he can multiply at pleaſure. The bud or ſmall branch, when united to the wild ſtock, retains that individual quality which it could not tranſmit by its ſeed; and, in order to produce the ſame fruit as its original parent, it requires only to be developed. The fruits receive none of the bad qualities of the wild ſtock; becauſe it has not contributed to their formation: It is not their mother, but their nurſe, which only aſſiſts their growth by conveying nouriſhment to them.

In the animal kingdom, moſt of thoſe qualities which appear to be individual, are propagated and tranſmitted in the ſame manner as their ſpecific qualities. It was, therefore, more eaſy for man to have influence upon the nature of animals than upon that of vegetables. Particular races in any ſpecies of animals are only conſtant varieties which are perpetuated by generation. But, in the vegetable kingdom, there are no races, no varieties ſo conſtant, as to be perpetuated by reproduction. In the ſpecies of the hen and pigeon, a great number of races have been very lately produced, all of which propagate their kinds. In other ſpecies, we daily rear and improve races by croſſing the breeds. From time to time, we naturalize and tame foreign or wild ſpecies. All theſe recent examples ſhow, that it was long before man knew the greatneſs of his power, and that he is not yet fully acquainted with its extent: It depends entirely on the exerciſe of his intellect. Thus the more he ſhall obſerve and cultivate nature, the more expedients he will diſcover for making her ſubmit, and for drawing from her boſom freſh ſources of riches, without diminiſhing the inexhauſtible treaſures of her fertility.

What influence might not man acquire over his own ſpecies, if his inclinations were always directed by his intelligence? Who knows to what degree he might improve his moral as well as his phyſical nature? Is there a ſingle nation who can boaſt of having arrived at the beſt of poſſible governments, a government which would render all men not equally happy, but leſs unequally miſerable, by attending to their preſervation, by ſoftening their labours, and ſparing their blood by cultivating peace and procuring abundance of proviſions: This is the moral end of every ſociety of men who are anxious to improve their condition: And, with regard to the phyſical part of our nature, have the medical and other arts, whoſe objects are health and preſervation, made an equal progreſs as the arts of deſtruction invented for the purpoſes of war and carnage? In all ages, it appears that man has reflected deeper and made more reſearches concerning evil than good. In every ſociety there is a mixture of both; and as, of all ſentiments which affect the multitude, fear is the moſt powerful, great talents in the art of doing miſchief were the firſt which ſtruck the mind of man; he was afterwards occupied with the arts of amuſement; and it was not till after long experience in theſe two means of falſe honour and unprofitable pleaſure, that he at laſt recogniſed his true glory to be ſcience, and his true happineſs peace.

THE END.

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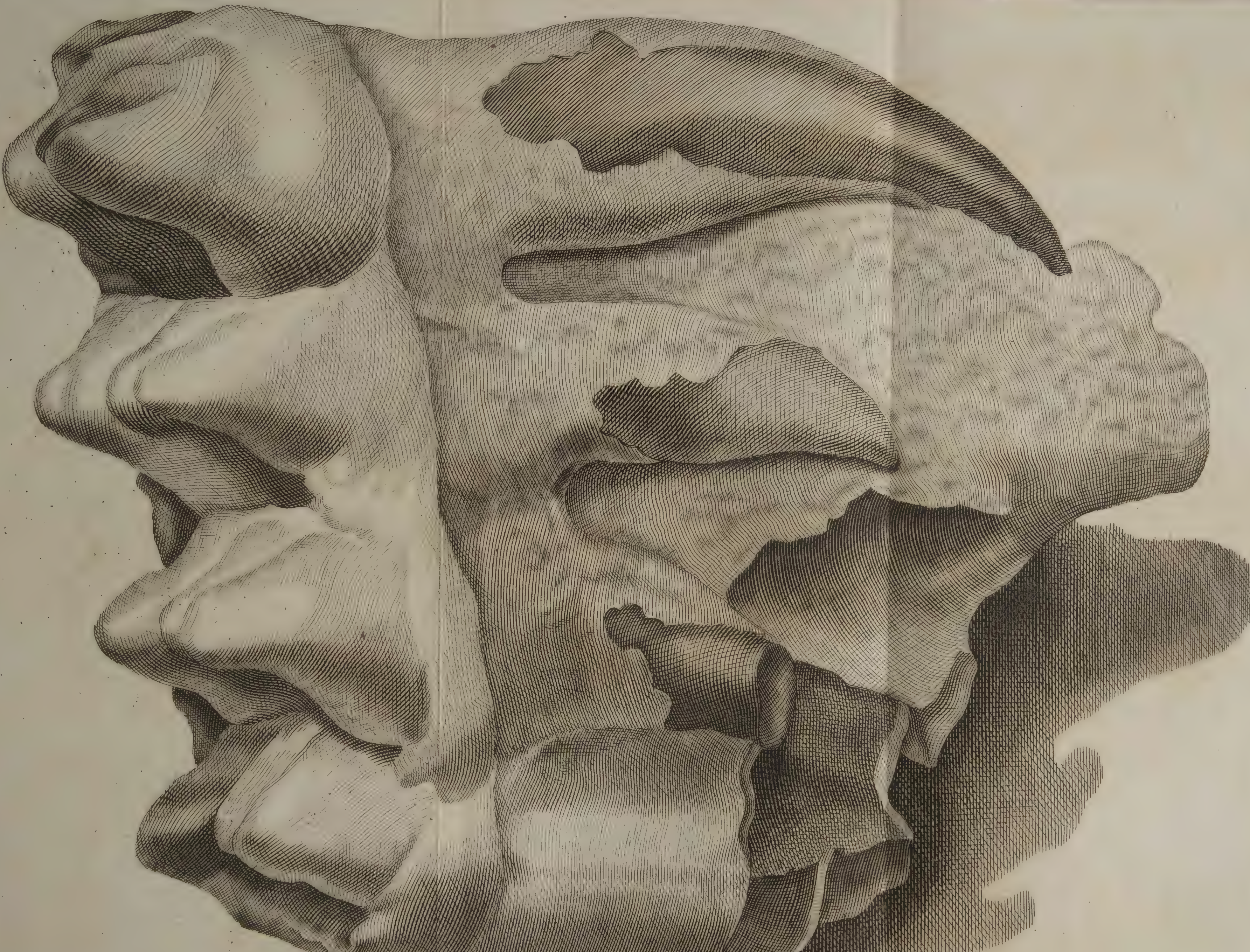

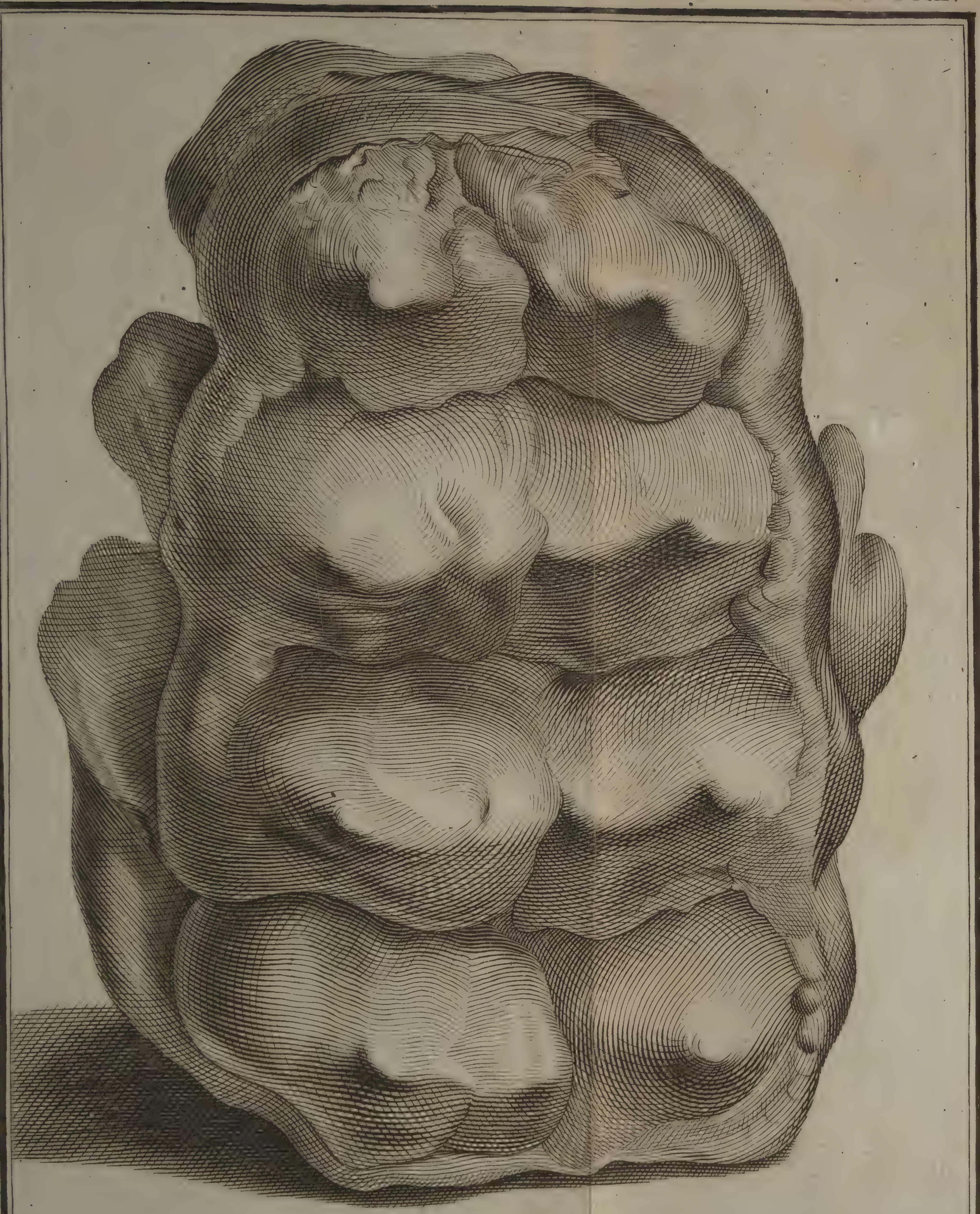

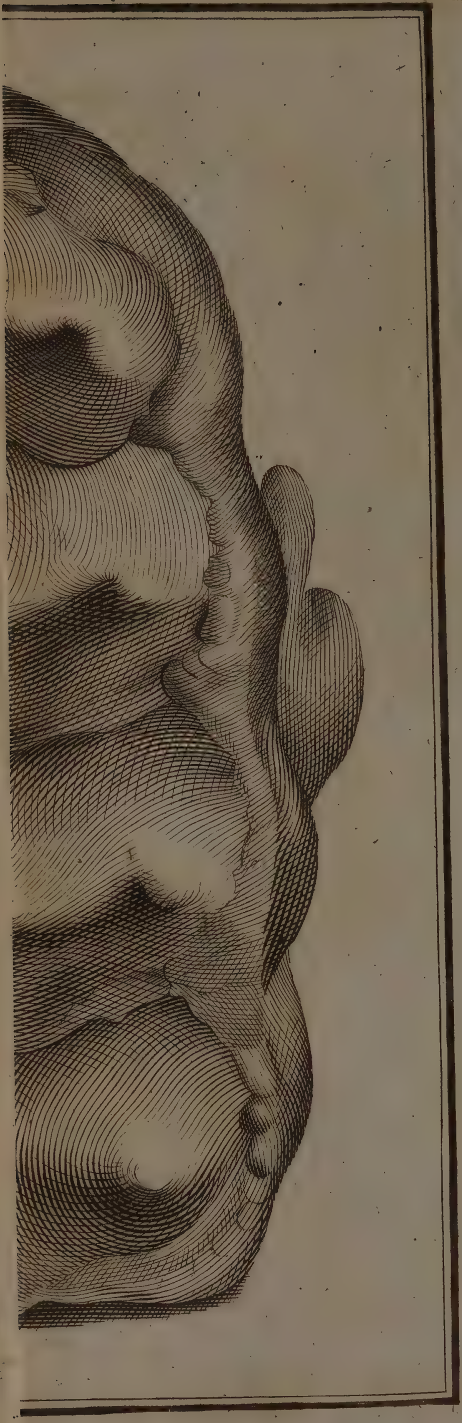
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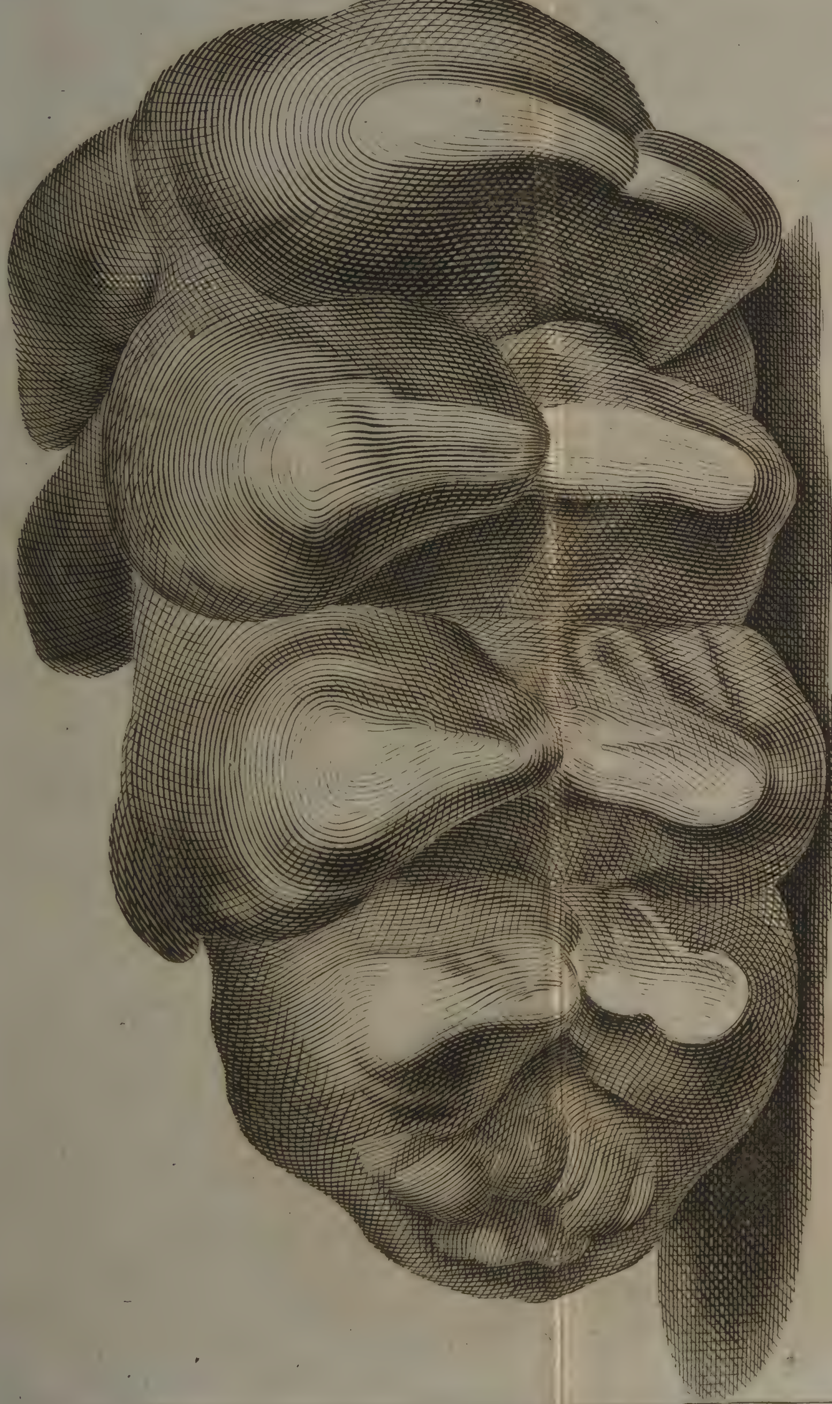

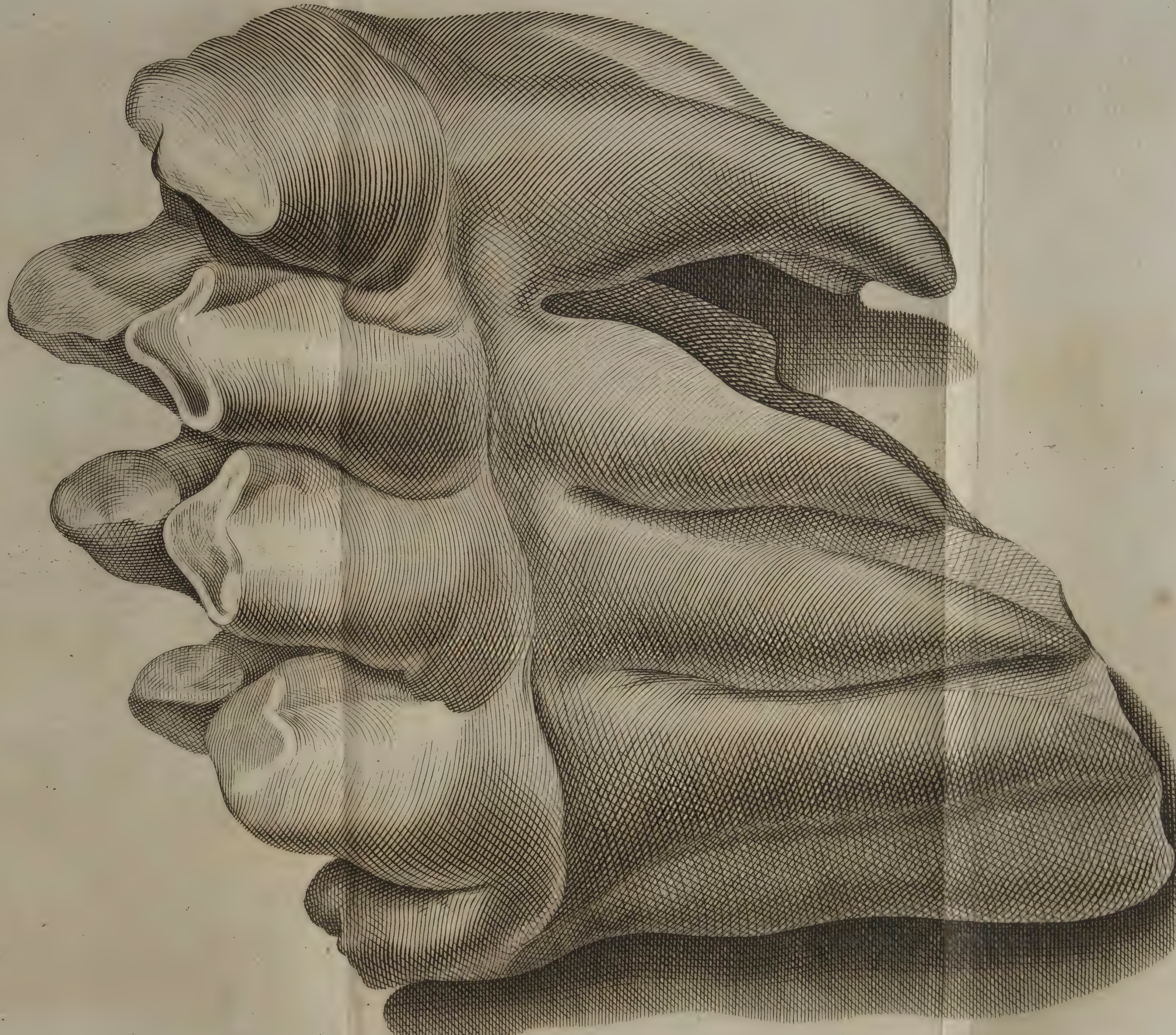

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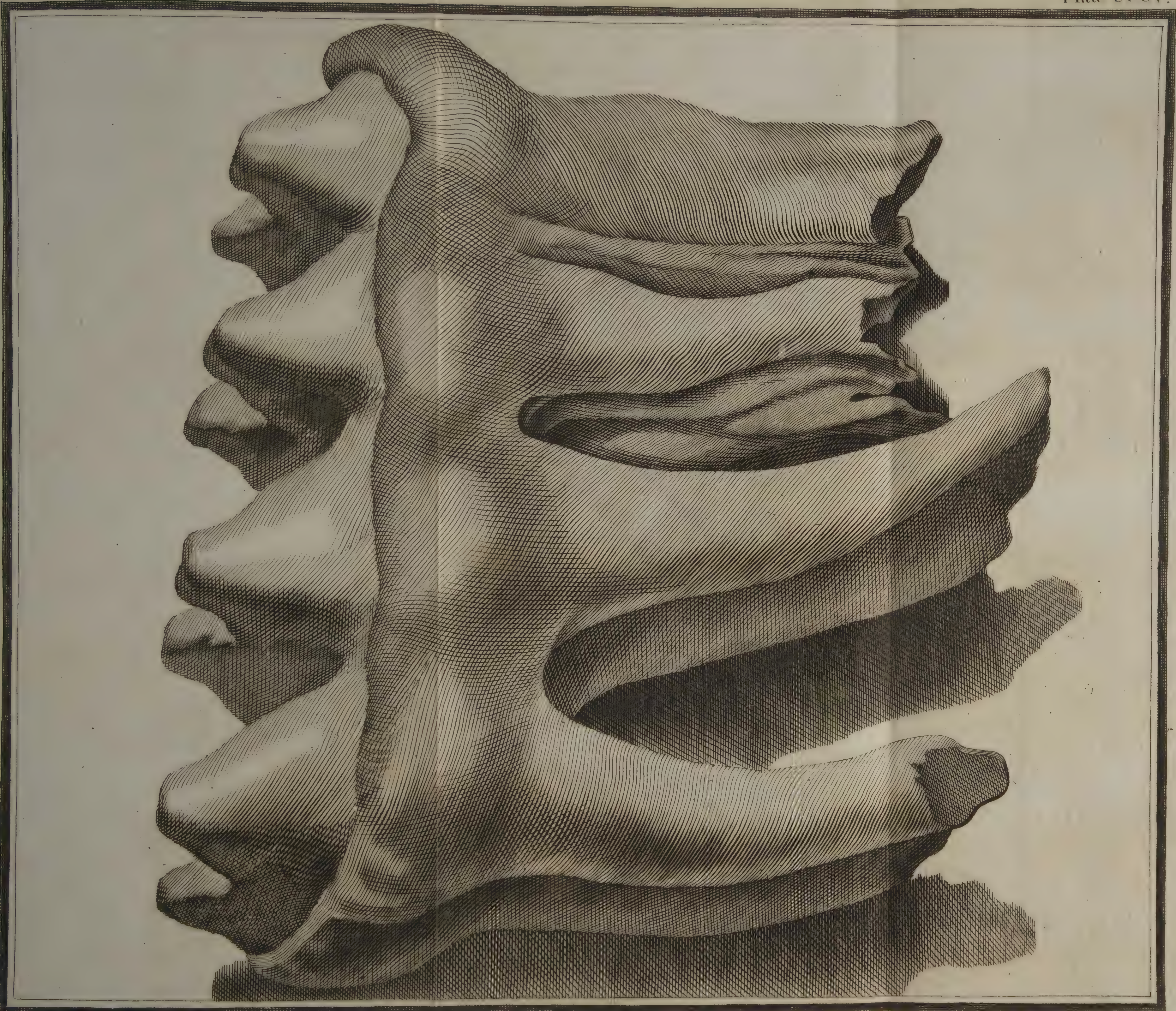

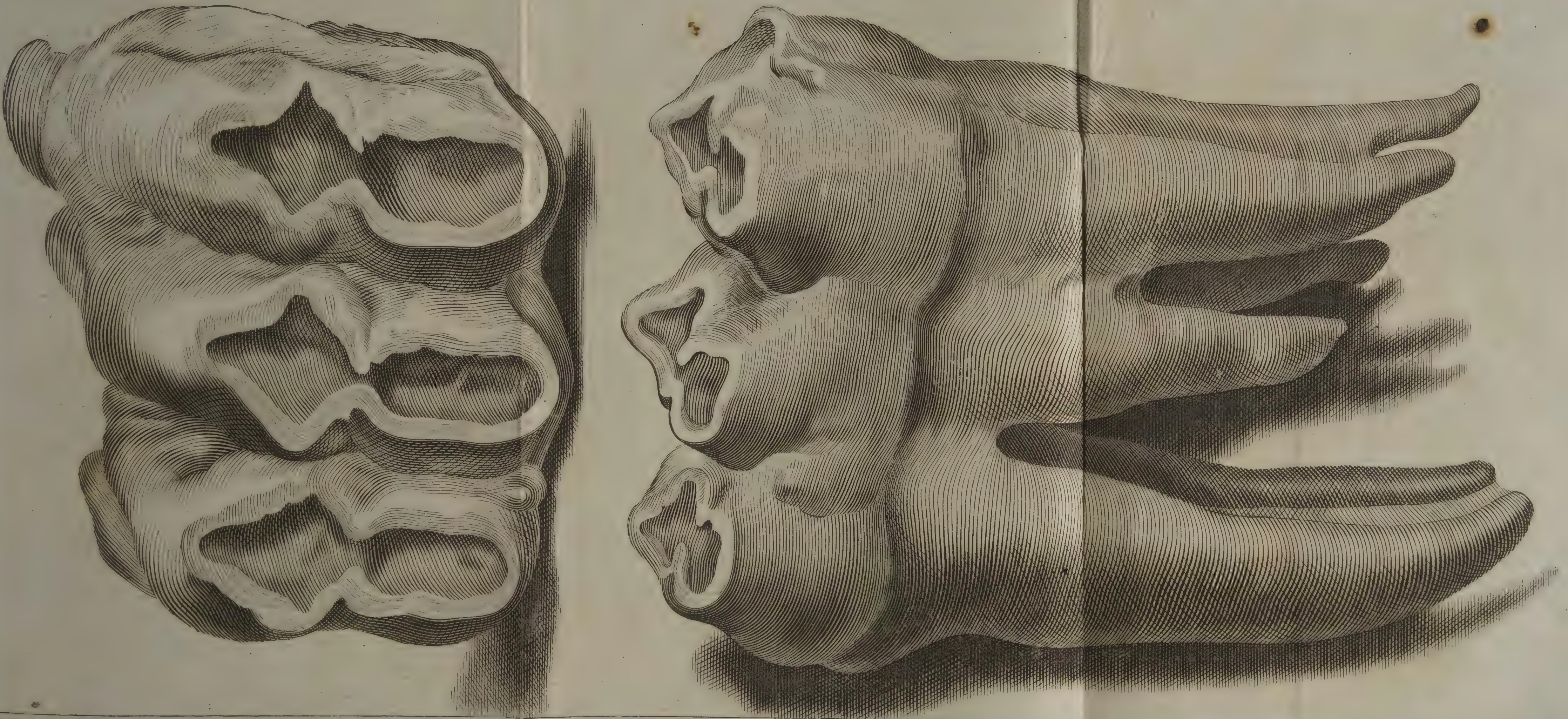

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